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AMERICAN JOURNAL OF OPTOMETRY *and* ARCHIVES *of* AMERICAN ACADEMY OF OPTOMETRY

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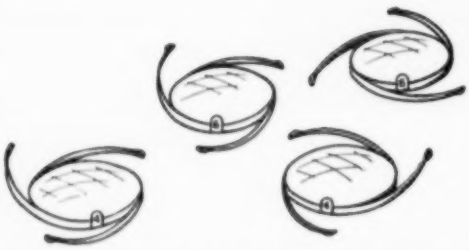

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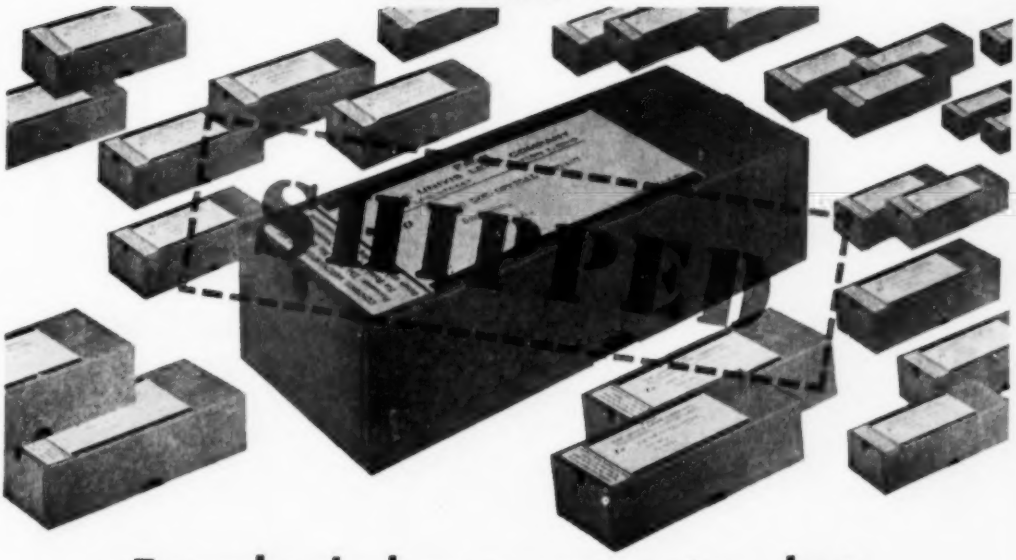

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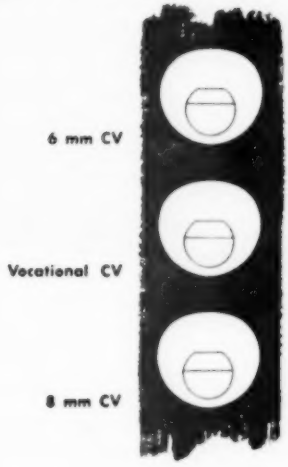

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Vol. 30 August, 1953 No. 8

AN INVESTIGATION OF THE TIME CHARACTERISTICS OF ACCOMMODATION AND CONVERGENCE OF THE EYES*

SUBJECTIVE DETERMINATION OF ACCOMMODATION AND OBJECTIVE RECORDING OF CONVERGENCE

Merrill J. Allen†
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Columbus, Ohio

This is a report of the equipment used and results obtained in a study of the speed of the accommodative act. The results are related to the corresponding convergence response which occurs automatically when accommodation is brought into play. A history of some of the studies related to this problem is given in reference 1.

1. EQUIPMENT

a. Haploscope and Targets

The basic unit of equipment was a haploscope. Figure 1 gives the optical layout. The targets which controlled fixation and accommodation were presented to the right eye by reflection at mirror M_1. The battery of mirrors M_2, M_3, M_4, shown in Figure 1 combine the three separate beams A, B and C into one common beam which would enter an eye placed at O. However, only one beam at a time was permitted to reach the subject. Two shutter blades not shown in the figure were placed just beneath the frosted glasses in beams A, B, and C. These shutter blades were imaged in the plane of the entrance pupil of the observer's right eye by lenses L_3, L_4; L_5, L_5 and L_5, L_6. The shutters were so arranged that the first shutter could occlude beam A or B, and the second could occlude beam C or B. Each shutter was controlled electrically and had a negligible operating time. By using different shutter blades and by actuating one or the other of the two shutters,

*Read before the annual meeting of the American Academy of Optometry, Rochester, New York, December 7, 1952. For publication in the August, 1953, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

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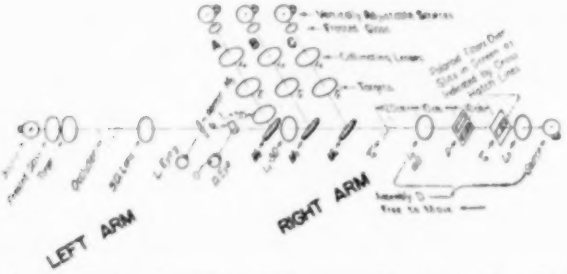

Fig. 1. Haploscope Optics. M_2, M_3, and M_4 are partial mirrors. Assembly D is used for the precise determination of the refractive state of the eye. The left eye occluder is removed only during the calibration of the convergence record. Shutters were placed below the frosted glass in beams A, B and C to permit exposure only one at a time of targets T_1, T_2 or T_3 to the right eye.

sequences of accommodative stimuli could be obtained such as follows: zero to two; zero to four; two to zero; four to zero diopters.

Paths A, B and C each contained identical photographic targets as shown in Figure 2. In path A the target could be moved through a

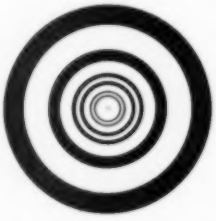

Fig. 2. The Accommodation and Fixation Target. The inside diameter of the smallest ring subtended five minutes of arc at the eye. The outside diameter of the largest ring subtended 9 degrees.

stimulus range of 0 to 5 D., in path B, 0 to 3 D., and in path C, 0 to 2 D. By virtue of the telecentric optical system (the secondary focal point of lens L_1 and of lens L_2 was located in the entrance pupil of the eye) changes in the position of the targets caused no variation in their angular size, and the dioptric changes which occurred were represented by a linear scale: in this case 1.00 D. = 4 cm. Dioptric values are here defined as the reciprocal of the distance from the entrance pupil of the eye to the target placed before the eye.

The left eye was effectively occluded during all phases of the experiment except that of calibrating the convergence record, but this occlusion did not interfere with the photographic recording of the convergence of the two eyes.

b. Accommodation Indicating Device

Assembly D of Figure 1 represents the principal of the accommodation measuring device. It is basically a Fry Optometer.[2, 3] A prism-lens system as described by Fry was actually used instead of the polaroid system shown in assembly D. However the polaroid system described below will illustrate its principal.

The two slits at P were imaged in the plane of the entrance pupil of the eye by lenses L_2, and L_3. The slit images were 2 mm. apart in the entrance pupil and each had a width of 0.2 mm. Figure 3, top

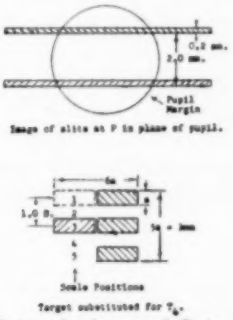

Fig. 3. The top drawing shows the image of P in the plane of the pupil. The lower drawing is the accommodation measuring target. This pattern was substituted for the pattern shown as T_4 in Figure 1, assembly D. When assembly D is moved so that T_4 (modified) is conjugate to the retina, the pointer will rest, as shown, at the number 3 position. Should T_4 not be conjugate to the retina, the pointer will accurately indicate the degree of deviation up to + or — 1.00 diopter.

drawing. An aerial image T'_4 of T_4 (see Figure 1) was produced by L_2. This aerial image of T_4 served as the accommodation measuring target. Polariod filters covered the slits at P and the two halves of the slit at T_4. The axes of polarization were oriented as indicated by the crosshatched lines. T'_4 moved along with assembly D and was always at a fixed distance from L_2.

T_4 was modified as shown in Figure 3, lower drawing, to enable the subject to estimate the amount of his accommodation in play at a given instant. When the subject was exactly accommodated for the plane of the target the "pointer" would exactly line up with the middle bar on the scale (position 3). When the subject was over accommodated the pointer would be displaced downward, when under accommodated it would be displaced upward. Polaroid filters were placed before this target (see Figure 1, T_4 and Figure 3) in such a way that the light which entered the eye to form the retinal image of the pointer, passed through the top portion of the pupil, while the

light for the scale passed through the bottom portion of the pupil.

A fast acting electrical shutter was placed between the source and L_7 of Assembly D to provide short single exposures of the modified T_4 pattern.

c. Convergence Recording Device

The American Optical Company Ophthalmograph designed for recording eye movements during reading was modified by changing the film speed from ½" to 1" per second and by adding a shutter (see Figure 4), and a neon light time marking device. Spring clips were attached to the adjustable lens tubes of the instrument to ensure that the adjustments of focus and alignment would not change during the experiment.

The ophthalmograph uses light reflected from the cornea to track the position of the eyes. A 2.5 V. flash light bulb was placed in the median saggital plane of the subject, 2½ inches below the level of his eyes and about 6 inches from the root of his nose. The arrangement of the light source, the ophthalmograph and the haploscope mirrors M_1

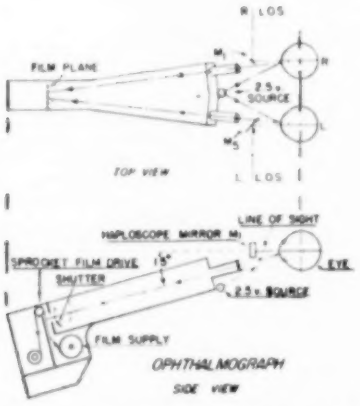

Fig. 4. Ophthalmograph. Schematic drawing of the essential parts of the camera used to record convergence.

and M_5 can be seen in Figure 4. The haploscope mirrors, do not interfere with the photographic recording of the corneal images.

d. Time Controls

A mechanical timer controlled the change from one accommodative target to another, the starting and stopping of the camera, the shutter before the film and the exposure of the measuring target of assembly D. In the serial order experiments one setting of the timer could be made

for every five accommodative trials. In the random order experiment, the time that the measuring stimulus lagged behind the change in the accommodative stimulus had to be changed randomly for each succeeding exposure to any one of twenty possible intervals from zero to one full second. A differential was added to the one revolution per second shaft of the timer so that the position of a cam on the rotating member of the differential could be adjusted by setting the stationary member. A handle which snapped into detents located at each of twenty positions was attached to the stationary member. Each position was separated from the next by 50 sigma.

The cam operated a switch which energized the shutter at L_1 to give a short exposure of the accommodation measuring stimulus. This switch also controlled a shutter which marked the convergence record at the same moment. Earlier, this same shutter controlled by the timer, marked the convergence record at the moment of change of the accommodative stimulus. Since the film record was thus marked at the two points where measurements of convergence were to be made, the analysis of the film was easier and more accurate.

2. PROCEDURE

Fifty sigma time intervals up to one second were chosen to sample the accommodation responses and each time interval was randomly used five times to give a total of 100 trials for a single accommodation curve (see Figure 5). When presented the accommodative stimulus, the subject responded by accommodating, and at a measured fraction of a second later when the measuring target was briefly presented to him he had to note the position of the pointer on the scale. This gave a measure of his accommodative achievement in the time allotted.

The first data were obtained from a serial order of presenting the accommodation measuring scale; that is, five presentations were made at 0.05 second, five at 0.10 second, five at 0.15 second, and so on to 0.40 second. From 0.40 to 1.00 second five presentations were given at every 0.10 second interval.

The accommodation measuring device containing the target shown in Figure 3, was so designed that a displacement of the pointer from the number 3 position to the number 4 or to the number 2 position represented 0.50 diopter of accommodative change. If the pointer were to be displaced from alignment with the number 1 scale position to alignment with the number 5 position, an accommodative increase of 2.00 diopters would be required.

The ± 1 D. limits of this device made it necessary to shift the

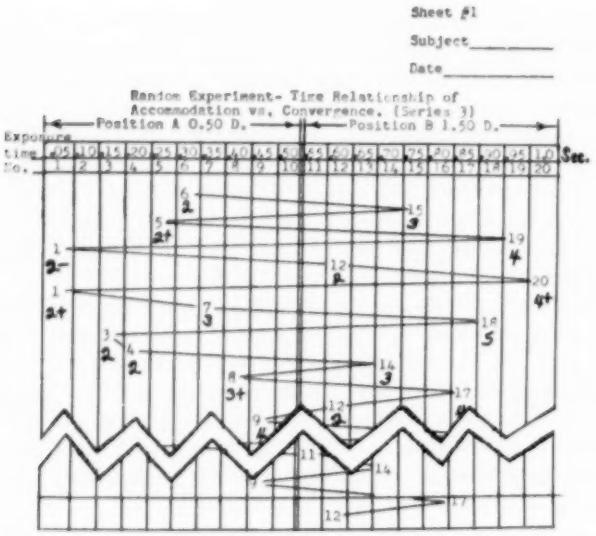

Fig. 5. Sample Record Sheets. Actual record sheets # 1, 2 and 3 used for random sampling of the accommodative response to a 2 D. change in stimulus. Positions A and B are the settings of assembly D to bring the accommodation measuring scale (Figure 3) to the accommodative achievement range to be expected in the first and last ½ seconds of the accommodative response. A sample of the method of recording has been penciled in on sheet 1. When assembly D was set at position A, the #3 position of the pointer (Figure 3) corresponded with 0.50 diopter of accommodation; when set at position B, the #3 pointer position corresponded with 1.50 diopters of accommodation.

target assembly D to two different dioptric positions in order that a satisfactory coverage of the range of accommodation being tested was available. The positions chosen were A, 0.50 diopter, and B, 1.50 diopters. The order of setting assembly D to position A and B was determined from the record sheet which had the predetermined random order recorded on it (see Figure 5).

A fore signal of 2 seconds was used to alert the subject. Any response which showed anticipation of the change of targets was discarded.

The subject was instructed to occupy himself with the accommodative act only, and to report what he saw when the short exposure of the measuring target was given to him. To ensure accommodative disregard of the measuring stimulus, occasional trials were given in which the measuring stimulus was omitted entirely. At first this caused some frustration, but by the end of the two practice series, each on a separate day, the subject had gotten the idea.

3. **RESULT:**

The data were obtained for a dioptric change of from zero to two diopters and the points presented represent the average of five observations except where otherwise noted. The abscissa scale covers one second of time. The ordinate scale to the left is in diopters for accommodation and the ordinate scale to the right is in degrees of inward deviation of the left eye for convergence.

Subject H.W.H., see Figure 6, has a very low accommodative convergence, accommodation ratio and the large fluctuations seen in his convergence data are actually less than one-half of a degree in extent. His accommodation record should be normal and seems to show about an average irregularity. The apparent real lag of accommodation behind convergence is not conclusive in view of the considerable irregularity and extremely low amplitude of the convergence data. The average deviation at time 0.35 seconds is ± .083 diopters for accommodation and ± 0.35 degrees for convergence.

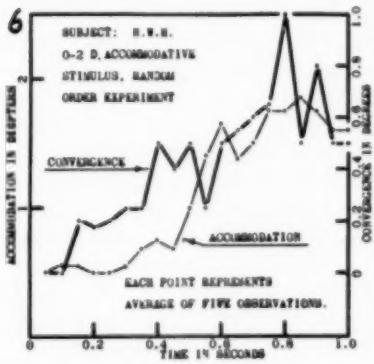

Fig. 6

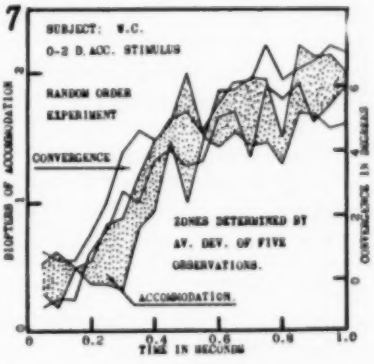

Fig. 7

The data of subject W. C., Figure 7, are plotted as the limits imposed by the average deviation about the mean of five observations at each time interval. Accommodation and convergence values appear to be well separated between 0.2 and 0.3 second but overlap in all other regions.

Subject G. A. F., Figure 8, seems to demonstrate a distinct lag of accommodation behind convergence. Each point is an average of five observations. The average deviation at 0.35 second is ± 0.24 diopters for accommodation and ± 1.50 degrees for convergence.

Figure 9, subject G. A. F., presents the serial order data as the average deviation from the average of the means of four experiments.

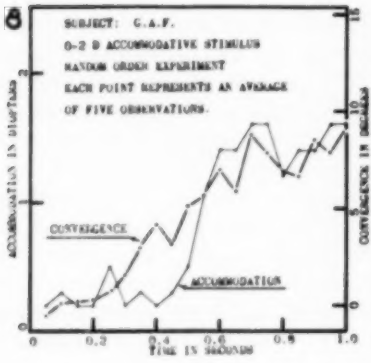

Fig. 8

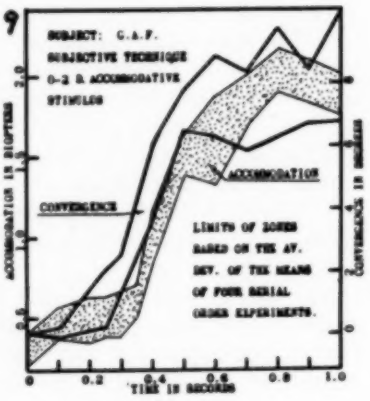

Fig. 9

The midpoint of the zone represents the average of the means of the four experiments while the limits are separated from this point by the average deviation of the four means. It appears that there is some real separation between convergence and accommodation in the early portions of the responses.

The curves for subject M. J. A., Figure 10 are much the same as those already plotted. The maximum amplitudes have not been properly equated in that at one second the average of the 20 observations for convergence has been plotted too high compared to the average of the 20 observations for accommodation. This raises the convergence

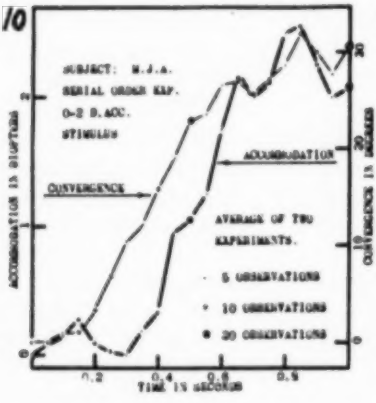

Fig. 10

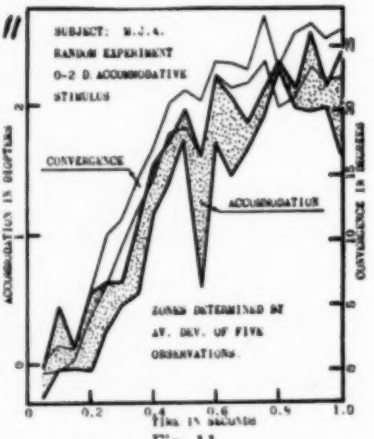

Fig. 11

curve somewhat more than should be permitted on the basis of this data alone. The average deviation from the mean at time 0.50 second (where 24 actual observations were made) was ± 0.73 diopters for accommodation and ± 6.0 degrees for convergence. These average deviations are higher than in the random experiment, Figure 11, probably because the points are the average of two experiments conducted two weeks apart.

Figure 11 presents the results of a random order experiment using subject M. J. A. There appears to be an appreciable separation between the convergence and accommodation responses. The data are presented as zones determined by the average deviation of five observations on either side of the mean. Here as in Figure 10 above, the maximum for convergence has been set slightly too high as based on this data alone.

4. SUMMARY AND CONCLUSIONS

A tachistoscopic method of measuring accommodation with respect to time is presented. While one eye fixated the accommodative target, the convergence of the other eye was simultaneously recorded by means of an ophthalmograph. Appropriate time marks on the film were used to relate the convergence response to the accommodation response.

The data obtained during a single one hour experiment represented the samplings from 100 accommodative acts. These samples taken at various time intervals following the change in the accommodative stimulus were then appropriately averaged and plotted to give an average accommodative response curve. Corresponding measurements from each convergence response film record were appropriately averaged and plotted along with the accommodative responses.

The resulting curves showed that convergence commenced sooner and increased relatively faster than did accommodation. The reaction time was estimated from these curves to be 0.2 second for convergence and 0.3 second for accommodation. In all instances these averaged curves showed that up to two diopters of accommodation (the maximum used) occurred within one second. All subjects except M. J. A. showed a tendency to under accommodate for a 2 D. stimulus and over accommodate when the stimulus was 0 diopters.

A separate study on the reaction time of the smooth muscle tissues of the ciliary body[4] has shown that the latent period of this muscle is considerable—of the order of 0.1 to 0.2 second or more. The latent period of the internal rectus muscle is neglible[5] being of the order of 0.001 second. It can be assumed that the differences in the speed of the

impulse along the two types of nerves involved (somatic and autonomic) are negligible because the total distance traveled by any of the impulses from the third nerve to the eye is very short.

Thus it is likely that the innervation fed to accommodation is simultaneously fed to convergence and the apparent lead of convergence of about 0.1 second is due, at least in part, to the long latent period of the ciliary muscle.

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[3]Fry, G. A., "Relation of Pupil Size to Accommodation and Convergence." American Journal of Optometry and Archives of American Academy of Optometry, Vol. 22. (Oct., 1945), pp. 451-65.

[4]Allen, M. J., "The Response of the Intraocular Muscles of the Dog and Cat to Electrical Stimulation." American Journal of Optometry and Archives of the American Academy of Optometry. June, 1950.

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BOOKS RECEIVED

The following newly published books have been received during the past month. As space permits, Reviews of these will be presented in future issues of the JOURNAL.

Die Schwimmende Hornhautlinse, by von Dr. Otto Knusel. Published by S. Karger, Holbeinstrasse 22, Basel, Switzerland. 63 pages. Illustrated. 3 color plates. Board covers. Swiss franks 7.30. 1953.

Contact Lens Practice, by Newton K. Wesley, O.D., and George N. Jessen, O.D. Published by The Professional Press, Inc., 5 N. Wabash Ave., Chicago, Illinois. 109 pages. Illustrated. Cloth. $4.00. 1953.

Manual of Ocular Tests and Requirements, by the Council of Education and Professional Guidance. The American Optometric Association, 404 Wilmac Bldg., Minneapolis, Minnesota. Third edition. 79 pages. Board covers. $3.50. 1953.

Differential Diagnosis of Common Diseases of the Eyeground, by Paul Tower, M.D. Published by Grune & Stratton, Inc., 381 Fourth Ave., New York 16, New York. 243 pages. Illustrated. Cloth. $10.00. 1953.

THE VARIATION OF PROXIMAL CONVERGENCE WITH CHANGE IN DISTANCE*

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The effect of the awareness of nearness on convergence and accommodation has in recent years been investigated from many aspects. Although the existence of proximal accommodation is disputed, the existence of proximal convergence (psychic convergence), which may be defined as convergence changes induced by the apparent nearness of the fixation object, is generally accepted.

Hofstetter[1, 2] found that proximal convergence appeared independent of changes in accommodation, that it appeared uninfluenced by the amount of accommodation or accommodative convergence present, and that it was closely associated with the amount of fusional convergence in play, but of a different neurological origin than fusional convergence. In measuring the average amounts of proximal convergence present between a 6 M. and 33.3 cm. testing distance, Hofstetter found 1.5Δ, 2.6Δ, and 7.6Δ for the base-in, phoria, and base-out lines respectively.

Ittelson and Ames[3] found changes in convergence associated with changes in perceived distance of the test object while the actual testing distance remained constant. However, these changes have since been attributed to accommodative-convergence[4] rather than proximal convergence. Neumueller[5] found in comparing phorias taken with a stereoscope to phorias measured in a conventional manner, that more convergence was present in the stereoscopic findings than for the findings taken in the conventional manner, although the amounts varied considerably with the subjects. Morgan,[6] in determining the mean accommodative convergence present in 413 subjects at a 40 cm. fixation distance, found it to be 9.1Δ by the gradient method and 12.6Δ by the phoria method (that is, measuring the 6 M. phoria and the 40 cm. phoria and making the appropriate calculations). The difference

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The authors express thanks to Drs. Hofstetter, Hirsch and Weymouth for their assistance.
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between these two means (3.5Δ) was attributed to the inclusion of psychic convergence by the phoria method and its exclusion by the gradient method. Morgan,[7] in an earlier investigation, noted the presence of convergence over and above that which could be attributed to "tonicity" or accommodative convergence at a 40 cm. testing distance. By plotting the actual accommodative response to accommodative convergence he determined the change in convergence per diopter change in accommodative response. Knowing this and the far point phoria, he compared this total to the amount of convergence actually present at this 40 cm. distance and found that convergence existed in excess of what could be attributed to "tonicity" and accommodative convergence. This added convergence, he concluded, was proximal convergence, the average being 3Δ ± 2Δ for fifty subjects.

Tait,[8] in comparing distance phorias with phorias taken at 33.3 cms. through +3.00 D. lenses, found an average difference of 5.8Δ which he attributed to the "proximal sense."

Although the above experiments furnished much information on proximal convergence, many unknown facts remained. Its variation as the fixation distance is gradually changed from infinity to near testing conditions; its change, if any, with different accommodative demands at these varied distances; the fixation distance at which proximal convergence first becomes a clinical entity; all had not been determined previous to this paper. To obtain information about these aspects of proximal convergence, the authors performed the investigation here reported.

EXPERIMENTAL PROCEDURE

One woman and seven men, students in optometry, ranging in age from 24 to 35, (the average age 28.5) served as subjects. All had normal, single, simultaneous, binocular vision and were correctable to 20/20 vision in each eye. Four subjects required no, or very minor, refractive corrections; two subjects were myopic, two hyperopic, two subjects had astigmatism of 1.75 and 2.00 diopters respectively.

The testing equipment included a phorometer mounted on a floor stand, and trial case lenses. The phorometer was fitted with rotary prisms and lens cells. The subject's interpupillary distance for fixation at infinity was used for all tests and the phorometer was so adjusted that the posterior lens cells were 14 mm. anterior to the corneal apices, the assumed position of the spectacle plane. The subject's distance correction was placed in the posterior cells, with the auxiliary lenses, which were used to create various accommodative demands, placed in the immediate adjacent cells; the auxiliary test lenses of most power were

placed closest to the eyes (immediately anterior to distance correction). The rotary prisms were mounted at a distance of 25 mm. anterior to the spectacle plane. Assuming the center of rotation of the eye to be 13 mm. posterior to the corneal apices, the rotary prisms were considered to be 52 mm. anterior to the centers of rotation of the subject's eyes. Six testing distances were used: the test chart employed at the 6 M., 2 M., and 1 M., distance was a projected line of letters requiring 20/20 acuity: at 50 cms., 40 cms., and 33.3 cms., 2 lines of printed words also requiring 20/20 vision were used. A rather dimly lighted room was used for all testing. The test card for the near tests at 50, 40, and 33.3 cms. was illuminated separately. Phorias were taken at each testing distance and, in order to provide complete testing data, six accommodative demands were presented at each testing distance. These demands were 0.00, 0.50, 1.00, 2.00, 2.50, and 3.00 diopters for each distance except 6 M.; at 6 M. the accommodative demands presented were 0.17, 0.67, 1.17, 2.17, 2.67, and 3.17 D. Thus, at 6 M. the phorias were taken with plano to minus three diopter lenses in addition to the subjective, at 33.3 cm. with plano to plus three diopter lenses, and at the other testing distances with appropriate amounts of plus or minus lenses. The testing sequence was designed to give as much uniform interval of change in distance between tests as was possible. Also, the sequence of accommodative demands was varied at each testing distance. The testing was performed, therefore, in the following manner:

1.	6 M testing distance	0.17 → 3.17 acc. demand
2.	50 cm. testing distance	3.00 → 0.00 acc. demand
3.	1 M. testing distance	0.00 → 3.00 acc. demand
4.	33.3 cm. testing distance	3.00 → 0.00 acc. demand
5.	2 M. testing distance	0.00 → 3.00 acc. demand
6.	40 cm. testing distance	3.00 → 0.00 acc. demand

Every finding plotted consisted of an average of four phorias, which in turn were recorded only after the subject demonstrated good consistency of response. When the subject showed such consistency, the four phorias were taken at that particular testing distance and accommodative demand, approaching vertical alignment alternately from right and left. To suspend fusion, 4Δ base-up was placed before the left eye for the 6 M. testing distance; 5Δ base-up for the 2 M., and 1 M. testing distance, and 6Δ base-up for the 50 cm., 40 cm., and 33.3 cm. testing distance. The subject was asked to fixate the bottom non-moving line, read this print aloud and to tap the chair arm with a pencil when perfect vertical alignment was noted. The subject was also informed that it was imperative to keep the print absolutely sharp and clear at all times. Occasionally under the varied testing conditions it took some time before

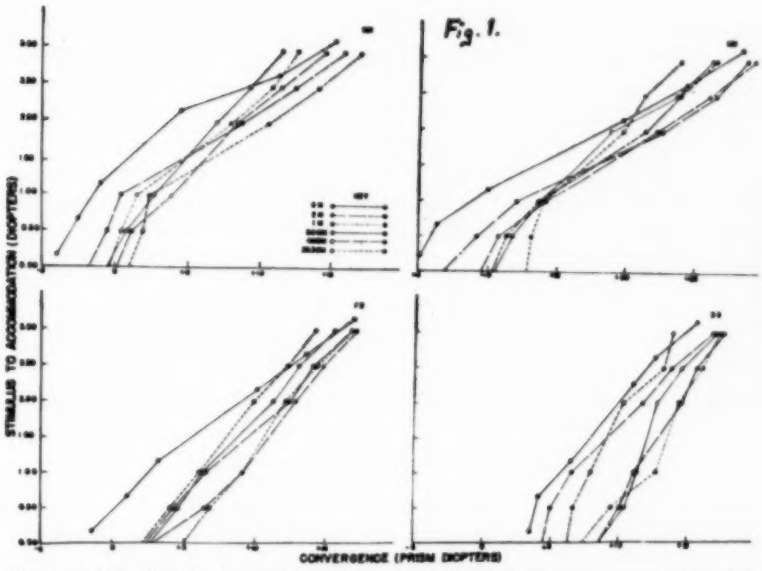
the print cleared. At times the print could not be cleared, in which case no findings were recorded. Every effort was made to have the subjects aware of each testing distance. At the nearer distances (50 cm., 40 cm., and 33.3 cm.) they were required to hold the target support with one hand during the testing.

Since the prism reading on the rotary prism scale represents convergence effective in the place of the prisms, a formula devised by Hofstetter[2] was employed to compute the actual convergence from the centers of rotation. This formula considers the subject's interpupillary distance, the distance of the lens cells from the centers of rotation, the distance of the plane of the rotary prisms from the centers of rotation, the distance of the test chart from the spectacle plane, the prism power reading from the rotary prism scale for the phoria, and the total dioptric power in the horizontal meridian of the lens cells. After all findings were thus calculated and corrected, graphs were constructed for each of the eight subjects, plotting accommodative demand in diopters on the ordinate and total convergence from the centers of rotation in prism diopters on the abscissa. Six gradient lines were thus plotted for each subject, one for each distance.

RESULTS AND DISCUSSION

An individual analysis of the eight cases presented in Figures 1 and 2 shows the following:

Case S. K. indicates a gradual increase in proximal convergence as the testing distance decreases, except for the 1 meter line. Case A. B. demonstrates no significant proximal convergence until the 50 cm. distance, and then maintains approximately the same amount at the 40 cm. and 33.3 cm. distances (the 1 meter distance was not tested during this series of tests but was taken in a later series, see Figure 7). Cases C. A., R. S., M. N., and H. M., all had similar pictures. The 2 M. and 1 M. lines are shifted to the right of the 6 M. line, especially at the lower demands to accommodation, indicating the introduction of proximal convergence at these distances. The three nearer testing distances manifest smaller slopes and interlace with the three further testing distances, with the 40 cm. and 33.3 cm. lines tending to the right of the 50 cm. line. There thus appears to be a different pattern of response present at the three nearer testing distances. Case F. S. demonstrates the greatest increase in proximal convergence between the 6 M. and 2 M. distances and between the 50 cm. and 40 cm. distances with the 2 M., 1 M., 50 cm. lines occupying essentially the same position at the lower accommodative demands. In case S. S. a gradual increase in proximal convergence appears present as the testing distance decreases to

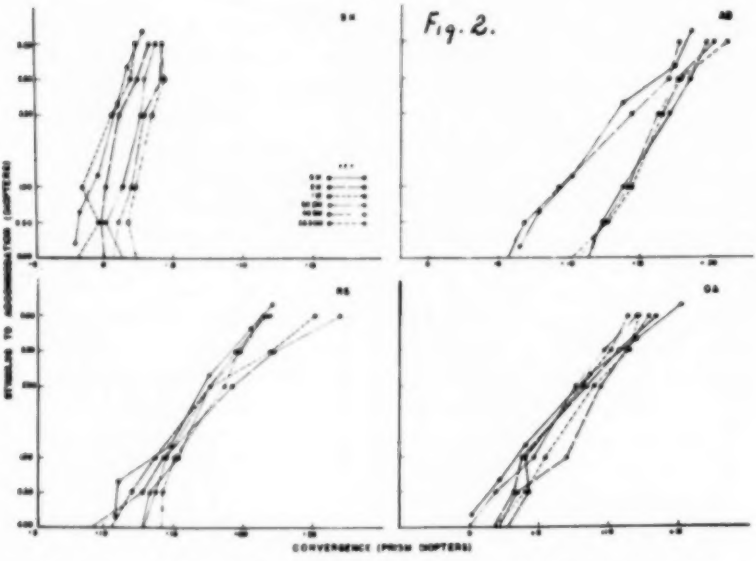


Figs. 1 and 2. Graphs of the eight subjects tested showing changes in convergence with change in distance and accommodative demand. The convergence data are corrected for effectivity at the centers of rotation and the accommodative data are for effectivity at the spectacle plane. Figure 2 on following page.

the 50 cm. distance, then the same approximate amount is maintaind at the 40 cm. and the 33.3 cm. distances.

The following basic characteristics can be noted in the eight cases: The 2 M. line was definitely displaced to the right of the 6 M. line in all but one case (A. B.), indicating the introduction of proximal convergence at this relatively far distance. The 1 M. line was to the right of the 2 M. line in six cases at the lower accommodative demands and tended to have a slope (of convergence referred to accommodation) less than either the 6 M. or 2 M. lines. The 50 cm., 40 cm., and 33.3 cm. lines, although demonstrating greater amount of interlacing at the upper accommodative demands with reductions in slope, on the average were displaced in sequence to the right of each other at the lower accommodative demands.

On the basis of these findings one may conclude that as the testing distance decreases, proximal convergence increases, especially when considering the lower testing levels of accommodation. The data suggest that there is a variation from individual to individual as to the distance proximal convergence first becomes manifest, the total amounts present,



and the rate of change of proximal convergence with change in distance. At the upper testing levels of accommodation there is a definite trend for all lines to meet, with less apparent displacement present, i.e., less manifest proximal convergence.

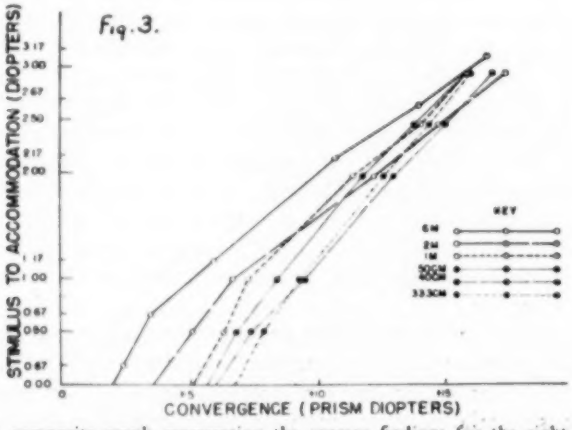


Fig. 3. A composite graph representing the average findings for the eight cases presented in Figures 1 and 2.

To obtain an overall picture of these clinical results, averages of all findings for the eight cases were made and a composite graph was constructed from them (Figure 3). From Figure 3 the trends previously mentioned become more obvious. A consistent displacement to the right is found as the testing distance is decreased at the lower levels of accommodation, while at the upper levels less displacement and interlacing is evident. A rank correlation of the order of testing distance with the amount of convergence present at the various accommodative demands shows the following: At 0 demand to accommodation, +1.00 correlation; at 0.50 D. demand, +1.00; at 1.00 D. demand, +0.943; at 2.00 D. demand, +0.771; at 2.50 D. demand +0.486, and at the 3.00 D. demand to accommodation, +0.557. Thus, the correlation declines as one goes from the lower to the higher accommodative demands where the differences in convergence (i.e., increase in proximal convergence) become less.

In Table I are presented the total average increases in proximal

TABLE I

PROXIMAL CONVERGENCE PRESENT FROM THE 6 METER DISTANCE

ACC.	2 METERS	1 METER	50 CM	40 CM	33.3 CM
0.00	+1.5Δ	+3.0Δ	+3.5Δ	+3.9Δ	+4.6Δ
0.50	+1.9Δ	+3.2Δ	+3.6Δ	+4.3Δ	+4.7Δ
1.00	+1.6Δ	+2.2Δ	+3.3Δ	+4.4Δ	+4.3Δ
2.00	+2.4Δ	+1.5Δ	+1.9Δ	+3.1Δ	+2.7Δ
2.50	+2.0Δ	+1.2Δ	+1.0Δ	+2.2Δ	+1.6Δ
3.00	+1.6Δ	+0.1Δ	+0.1Δ	+1.2Δ	+0.3Δ
Average	+1.8Δ	+1.9Δ	+2.3Δ	+3.2Δ	+3.0Δ

TABLE II

INCREASE IN PROXIMAL CONVERGENCE WITH CHANGE IN DISTANCE

ACC.	2 METERS	1 METER	50 CM	40 CM	33.3 CM
0.00	+1.5Δ	+1.5Δ	+0.5Δ	+0.4Δ	+0.7Δ
0.50	+1.9Δ	+1.3Δ	+0.4Δ	+0.7Δ	+0.4Δ
1.00	+1.6Δ	+0.6Δ	+1.1Δ	+1.1Δ	—0.1Δ
Average	+1.7Δ	+1.1Δ	+0.7Δ	+0.7Δ	+0.3Δ

convergence in prism diopters from the 6 M. gradient line for the various accommodative demands as found in Figure 3. From Table I the average amount of proximal convergence present at the various testing distances from the 6 M. line was found to be: 1.8Δ at 2 M., 1.9Δ at 1 M., 2.3Δ at 50 cm., 3.2Δ at 40 cm., and 3.0Δ at 33.3 cm. The average proximal convergence of 3.0Δ at 33.3 cm. compares closely with Hofstetter's[2] findings of 2.6Δ while the proximal convergence of

3.2Δ at 40 cm. compares well with Morgan's[7] findings of 3.0Δ. The picture is decidedly altered, however, if only the lower levels of accommodation are considered. It is the authors' opinion that since other factors are obviously being introduced at the higher accommodation levels, as evidenced by the changes in slopes and interlacing, that a more refined picture of proximal convergence may be obtained by considering the lower accommodative levels, not overall averages. This point was similarly made by Tait[16] who stated that proximal convergence could best be measured when both the accommodative and fusional convergence reflexes were not present as they are usually so much greater in amount that they would supersede the proximal reflex. The changes thus appear more consistent at the 0 demand to accommodation where 1.5Δ was found at 2 M., 3.0Δ at 1 M., 3.5Δ at 50 cm., 3.9Δ at 40 cm., and 4.6Δ at 33.3 cm. This latter amount compares favorably with Tait's[8] findings of 5.8Δ.

The variations in amounts of proximal convergence found with changes in distance at the six accommodative demands may be graphically demonstrated by plotting the reciprocal of the target distance on the ordinate and convergence on the abscissa (Figure 4). From this graph it

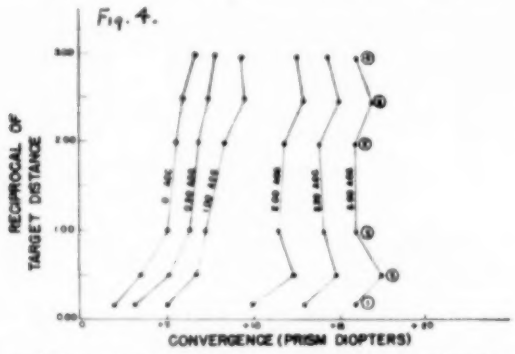


Fig. 4. The variation of proximal convergence with the reciprocal of the testing distance as found with average findings of the eight cases tested.

may be seen that the relationship between proximal convergence and the reciprocal of the distance is not represented by a straight line at the lower accommodative demands. Also, it may be noted that the last two testing distances (#5 — 2 M., #6 — 40 cm.) show greater amounts of convergence than would appear consistent, especially at the higher demands to accommodation. Since all tests on each subject were performed on one sustained occasion, this increased convergence may

indicate a secondary factor, possibly fatigue, being introduced towards the end of the testing with resultant increases in gradients.

Table II shows the increase of proximal convergence as the distance is decreased at the lower accommodative levels. In determining the rate of change of proximal convergence with change in distance, if the average increase of the lower accommodative levels (0.00 to 1.00 D.) be considered, it will be seen that proximal convergence tends to increase in an accelerated manner as the distance decreases. Thus, for a 4 M. change between the 6 M. and 2 M. distance, 0.004Δ per cm. change was obtained; for the 1 M. change between the 2 M. and 1 M. distance, 0.011Δ per cm. change was present; for the 50 cm. change, between 1 M. and 50 cm. distance, 0.014Δ per cm. change was found; for the 10 cm. change between the 50 cm. and 40 cm. distances, 0.070Δ per cm. change was obtained; and for the 6.7 cm. change between the 40 cm. and 33.3 cm. distances, 0.045Δ per cm. change was present.

As was mentioned earlier, definite changes in the slopes of the gradient lines were noted with a tendency for these lines to meet at the 3.00 D. level of accommodation (Figure 3). This same trend was present in Hofstetter's[2] work, i.e., the greatest amount of proximal convergence was found at the lower testing levels of accommodation with the 6 M. gradient line sloping toward and almost meeting the 33.3 cm. gradient line at the upper levels.

Upon close inspection it was found that not only did the slopes change with the testing distance, but a curvilinear relationship appeared

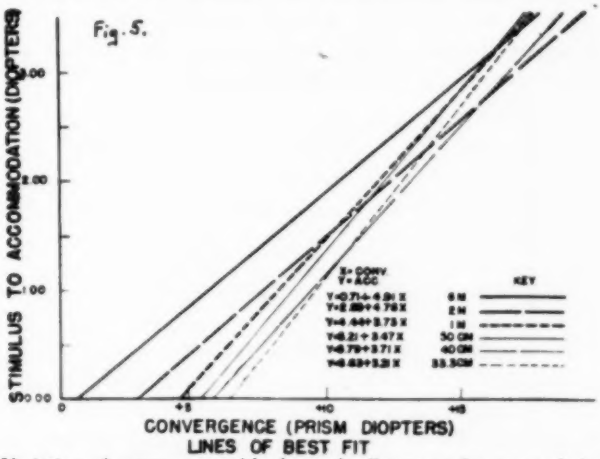


Fig. 5. Variation of convergence with change in distance and accommodative demand as indicated by lines of best fit: based on data presented in Figure 3.

to be present in some lines, being especially true of the 6 M. and 2 M. lines where the gradients were higher at the higher dioptric demands to accommodation. The majority of the lines, however, could best be fitted by a straight line and, thus, a graph was constructed (Figure 5) with statistically determined straight lines based on the information presented in Figure 3.

The slopes of the lines presented in Figure 5, as determined statistically, are as follows:

6 M line	——	4.91
2 M. line	——	4.76
1 M line	——	3.73
50 cm. line	——	3.47
40 cm. line	——	3.71
33.3 cm. line	——	3.21

This compares to the average gradients found from Figure 3 of:

6 M line	——	4.79
2 M. line	——	4.62
1 M line	——	3.61
50 cm. line	——	3.44
40 cm. line	——	3.68
33.3 cm. line	——	3.15

It may be seen that in both cases the slope drops in sequence with decrease in testing distance except for the 40 cm. line, the last distance at which tests were performed. The authors feel that this change in slope, together with the tendency for the gradients to be higher at the higher demands to accommodation at some distances, is of special clinical importance. On the basis of the above facts, decidedly different gradients may be found in the same individual when tested at different distances or different accommodative demands. This would suggest the need for special care in the use of the clinical gradient as a diagnostic test.

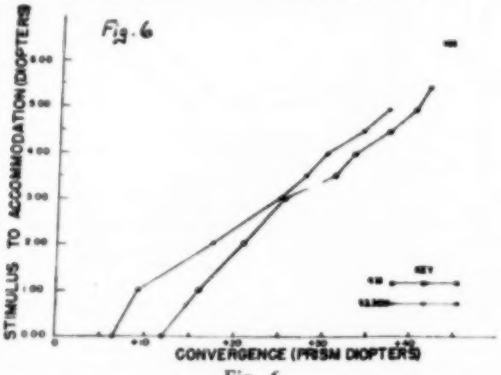
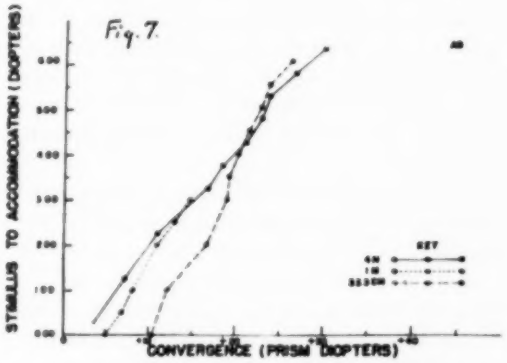
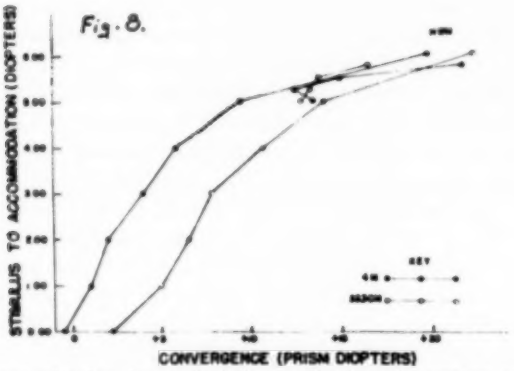


Fig. 6

Since the changes in slope with the tendency for the lines to meet at the 3.00 D. demand to accommodation was an unexpected occurrence, it was decided to test three subjects beyond the 3.00 D. demand to further investigate this aspect. The results of these tests appear in Figures 6, 7, and 8. Only two distances, 4 M. and 33.3 cm., were used (except case A. B.) and the accommodative demand ranged up to 6.25 D. Each case reacted differently above the 3.00 D. level. Case H. M. (Figure 6) demonstrates a 4 M. line sloping sharper than the 33.3 cm. line up to the 3.00 D. stimulus, then the response pattern seems to change with both lines having a similar slope. When originally tested (Figure 1), the 6 M. line actually crossed the 33.3 cm. line before the 3.00 level. However, the gradient in this case is high and slight variations in accommodative response would produce relatively large variations in convergence. Case A. B. (Figure 7) demonstrates an



average gradient smaller than H. M. The 1 M. and 33.3 cm. lines both intersect the 4 M. line, assuming positions of less convergence after the crossing points. A consistent change in slope appears present at all levels of accommodation in contrast to case H. M. The rate of introduction of proximal convergence is nicely shown by the displacement of the 1 M. and 33.3 cm. lines at the lower levels of accommodation. Case H. W. H. (Figure 8) demonstrates a small average gradient, hence variations in accommodative response would tend to alter convergence but slightly. Generally no great difference in slope between the two lines appears present. Noticeable, however, is the gradual increase in gradient as the higher accommodative levels are reached causing a curve in both lines. The findings between the 5.00 D. and 6.00 D. demand to accommodation were tested on two occasions. The plottings here represent



averages of ten phorias, instead of four. During the testing at this range a considerable difference in the magnitude of the phorias was found for each accommodative demand. The subject in this case was an extremely experienced and critical observer and stated that in each phoria measurement the print was sharply defined. It would thus appear that some other factor was being introduced as the maximum limit of the accommodative amplitude was reached which caused convergence to increase and fluctuate.

In attempting to account for the changes in gradients found at the various distances and accommodative demands many explanations may be given: The depth of focus present would allow a certain amount of variation in accommodative response, below or in excess of that demanded, with the maintenance of sharp vision. Also, it is known that the pupillary diameter decreases with increased accommodation.[10, 11] This change in pupillary diameter would permit an even greater freedom to accommodative response from the resultant increase in the depth of focus. Further, the accommodative response may tend to be on the far side of the depth of focus under certain conditions and on the near side of the depth of focus under other conditions. That is, the relationship of the accommodative response to demand may vary at different distances; and the creation of accommodative demands, greater or less than normal for a specific distance, may alter the pattern of accommodative response. Morgan[7, 13] and other investigators,[12] for example, have found that when fixating at a 40 cm. or 33.3 cm. distance the accommodative response tends to lag behind the demand, while at zero demands to accommodation the accommodative response was in excess of the demand. Morgan[7] also found a tendency for a greater accommodative response in relation to demands presented at a 1 meter distance than at

a 25 cm. distance. Noted during the testing was the difficulty all subjects had in meeting the higher accommodative demands (2.00 — 5.00 D.) at the 6 M. and 2 M. distances and the relative ease in overcoming these same demands at the nearer testing distances. It may be reasoned that the higher accommodative demands at the further testing distances which were extremely unfamiliar were not met with the same accommodative response as was the same demand at the nearer testing distances.

Another possible theory is that an actual change in the accommodative convergence/accommodation ratio occurred. Alperin[1] found that when the ciliary muscle was partially paralized with drugs, an increase in the A. C. A. ratio was obtained. A like result may occur when unusual or very difficult demands to accommodation are made, especially when these demands approach the limits of the amplitude of accommodation. The factor of increased tonicity or fatigue noted earlier (Figure 5) may similarly affect the apparent A. C. A. ratio.

It may also be stated that positive fusional convergence is being introduced in some instances even though no fusion is present, a possibility mentioned by Morgan.[9] Its introduction may account for the extreme variations in phorias found in case H. W. H. at the higher demands to accommodation.

Another factor which may partially account for the change in slopes is the fact that the subjects held the test target when the phorias were measured at the 50 cm., 40 cm., and 33.3 cm. distances. Hom and Morgan[10] found that the gradients were less when the subjects held the test target than when the target was not held.

The fact that the image size was altered with the addition of plus and minus lenses is another consideration which could have affected the findings.

The authors believe that any or all of the possibilities discussed above may have entered into and influenced the findings to varying degrees as the testing distance and accommodative demand varied.

SUMMARY AND CONCLUSIONS

1. As the testing distance decreases proximal convergence increases.
2. The rate of increase, the distance proximal convergence first became evident, and the amounts of proximal convergence found, as shown in eight subjects, varied with the individual.
3. Proximal convergence begins to take effect even at a 2 meter distance.
4. The rate of increase of proximal convergence, on the average, increases with decrease in distance.

5. Proximal convergence may be more easily and consistently determined at lower levels of accommodation.

6. Less proximal convergence was manifest at the upper levels of accommodation than at the lower levels.

7. Changes in gradients were obtained with change in distance and accommodative demand. Various factors are discussed which could account for these changes.

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THE EFFECT OF STIMULUS SIZE AND RETINAL ILLUMINANCE ON THE HUMAN ELECTRORETINOGRAM*

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INTRODUCTION

When a light stimulus is presented to an eye, a characteristic electrical potential is generated. This potential, called the illumination or action potential of the retina, may be picked up by electrodes, and recorded on an oscillograph. The recording is called an electroretinogram (ERG).

The ERG has, classically, three waves: a small, quick, negative one followed by a large positive one which in turn is followed by a relatively slow positive wave. These have been termed by Einthoven and Jolly[1] *a*, *b* and *c* respectively. A small positive wave sometimes appears after cessation of the light stimulus and is called the *d*-wave. This off-effect is never found in the human ERG.

Granit[2] has investigated three apparently basic underlying processes in the illumination potential which sum to yield the ERG. Recent investigations[3] have confirmed Granit's view that these processes

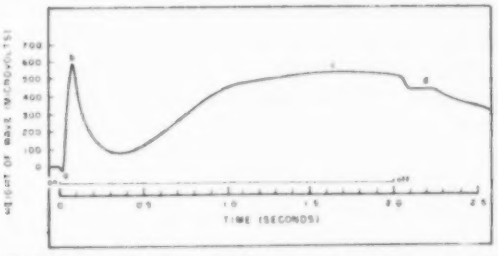

Fig. 1. A classical electroretinogram of the type found in man. (Redrawn from Granit.) The *d*-wave or off-effect is never found in man.

are an oversimplification of the mass electrical phenomena of the retina, but it seems that the processes are still fundamentally sound. Figure 1

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is a classical representation of a mammalian ERG of the type found in human beings, redrawn from Granit.[2] Process (P) I contributes essentially to the *c*-wave; P II, to the *b*-wave, and P III to the *a*-wave. These processes have been separated by the use of various drugs and hypoxia.

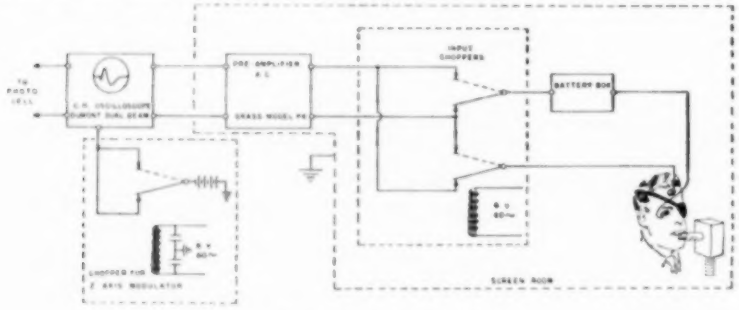
The human ERG has often been investigated. Holmgren in 1865 and Dewar & McKendrick in 1873 independently discovered it. While there is much older work in the field, only in recent years, has the human ERG been extensively investigated by Riggs[4] and his collaborators and, clinically, by Karpe[5] and his co-workers. Others have written about the human ERG to a lesser extent.

Germane to the present study, Boynton and Riggs[4f] investigated the effect of stimulus area and retinal illuminance on the ERG. They found that the light scattered by the ocular media was strong enough to dominate the ERG. Variation in the size of the stimulus up to a maximum diameter of 12°, but with a constant total luminous flux caused no obvious changes in the ERG.

The purpose of this paper is to describe the changes in amplitude of the human ERG with varying retinal illuminance and stimulus size (up to 41°). The data will be viewed with particular reference to the effect of area of the stimulus on the ERG when the total luminous flux is constant.

APPARATUS

Recording Apparatus: Two systems were used, a direct current (D.C.) amplifier and an alternating current (A.C.) amplifier. The D.C. system, diagramed in Figure 2, consisted of a battery box (zero set) to nullify constant potentials from the electrodes and the subject. The circuit then led to a pair of Brown Converters (choppers) which



DIRECT CURRENT AMPLIFIER

Fig. 2. For explanation see text.

modulated the D.C. input signal with 60 cycle rectangular waves; consequently, the signal could be amplified by the 2 megohm input pre-amplifier. This pre-amplifier was a Grass P4, 4-stage capacity coupled and battery operated. The pre-amplifier, which had a time constant of 4/5 second,* controlled one beam of a cathode ray oscilloscope. A chopper system used for very high gain amplifiers has the serious disadvantage of producing large transient noise signals from the mechanical contacts of the choppers. Because of these, the system while more stable than a direct coupled D.C. amplifier does not necessarily yield as good sensitivity. These transients can be suppressed, however, by modulating the cathode ray oscilloscope (z-axis modulation) so that the beam is suppressed when the noise would appear. This is accomplished by connecting another similar chopper to the z-axis modulator and adjusting it so that the beam is not suppressed during the noiseless central portion of each rectangular wave. Hence, the D.C. amplifier system had the stability and sensitivity (stable at the noise level of $<3\mu$V.) of an A.C. amplifier. However, there was an upper frequency limitation of about 20 cycles which is characteristic of the 60 cycle carrier system. Also there were two traces of the beam, one the mirror image of the other. One of them was partially suppressed by adjustment of the z-axis chopper. An amplification was used such that a one millivolt signal deflected the oscilloscope beam 50 cm.

A Fairchild Oscillo-Record camera with an f 1.5 lens was used. Eastman Linagraph Ortho 35 mm. film recorded from the P-11 screen which presents short-persistence blue tracer with high photographic efficiency for the film used. The film was run at a constant speed of ½ inch/second and a built-in neon timer light registered on the film every 1/5 second.

The second beam of the oscilloscope was connected to a Weston Photronic cell which was mounted on the stimulus apparatus. It was used as a stimulus marker. Tests indicated that the lag in the barrier type photoelectric cell was not significant for measuring the times involved. However, it was found that the differential drift of the oscilloscope amplifiers and hence that of the beams was too great in relation to film speed (film motion was used as a time base) to yield time measurements of the ERG relative to stimulus time (latent periods).

The tracings on the film were measured with a millimeter rule after projection by a Spencer Microfilm Reader: the reader provided an easily measured image of the ERG 15 times the original size.

*Time constant based on time required for the output of a constant input signal to fall to 1/e or 37% of its maximum value.

The pre-amplifier provided calibration which was checked by a Calidyne "Calivolter" Model 3 (accurate to ¾ %). This check demonstrated that the Grass calibration was correct within 2½ %. The amplifier system gave a linear response over the part of the screen used.

The electrodes were of silver-silver chloride. They were made by electrolysis in sodium chloride solution with about +3 volts on the silver wire electrodes and the negative lead on a platinum one. Approximately 5 milliamperes per silver electrode were drawn for less than a minute and stopped when adequate chloridization was completed.

The specific or local electrode was mounted in a contact lens, a technique originated by Riggs.[4a] The contact lens had a special plastic

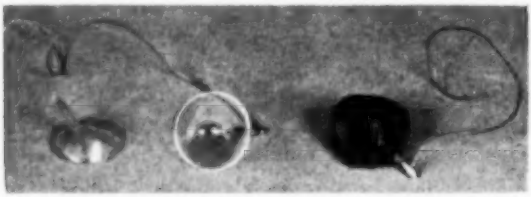


Fig. 3. Left: contact lens with plastic tube receptacle for an electrode. Center: similar contact lens with silver-silver chloride electrode in place. Right: rubber suction cup with remote electrode inserted.

tube to receive the electrode to facilitate its removal for recoating. This may be seen in Figure 3. The indifferent or remote electrode was mounted in a specially constructed rubber electrode cup, also shown in Figure 3,* which was filled with the same solution used in the contact lens and held on the forehead by suction. Light, flexible wires from both electrodes were held by alligator clips which were mounted through insulation on a leather head band. Shielded leads from the amplifier system plugged into the clips. Figure 4 shows the electrode arrangement. The subject's head was maintained in position firmly by a dental impression bite. The contact lens with electrode was mounted on the right eye and an occluding patch (not pictured) was placed over the left.

Stimulus Apparatus: The stimulus apparatus (Figure 5) consisted of the following. A projection type incandescent lamp with a small coil filament (G.E. 6v., 17 amp.) was energized by lead-acid batteries to avoid introducing electrical noise from without since the whole apparatus was within the screen room. A voltmeter across the battery allowed a monitor of the maintenance of the illuminance level during experimental sessions. Iris diaphragm D_1 controlled the

*Special care was taken to avoid bubbles which could interfere with the electrode.

Fig. 4. Subject fixed in position by a dental impression bite, with corneal and remote electrodes in place.

angular size of the stimulus ultimately entering the eye from a maximum of 41° to a minimum of 5°. The steps used were chosen arbitrarily by the convenient markings on the diaphragm. Compur shutter S controlled the duration of the stimulus. Diaphragm D_2 was imaged at the nodal point of the eye through lenses L_3, L_4 and L_5. Half-reflecting mirror M diverted part of the light beam to photoelectric cell P which provided the stimulus marker. Filter F consisted of Wratten neutral density filters. Lenses L_4 and L_5 formed a Ramsden eyepiece. An image of D_1 was focused in the plane of L_4 to provide sharp edges for the stimulus spot. The eye was placed at E so that the stimulus bundle entered the pupil (or nodal point) at the focal point of the optical system, thus providing a "Maxwellian view." At maximum field size, the bundle

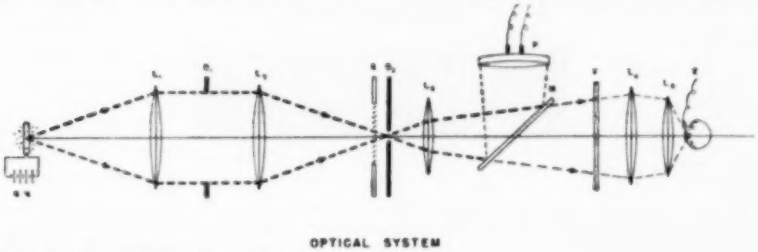


Fig. 5. For explanation see text.

was 5 mm. wide which was smaller than the dark adapted pupil.

A Macbeth Illuminometer was used to measure the luminance of the stimulus. It was found that without filters there was a stimulus luminance of 2,600 millilamberts. Stimulus luminance was directly proportional to retinal illuminance and could be considered as equal to it in milliphots assuming no absorption, reflection or scattering by the ocular media.

RESULTS

There is a marked change in the shape of the human ERG, when the size of the stimulus field is varied and retinal illuminance is kept constant. As the diameter of the stimulus is increased from 5° to 41°, the well-known *a*-wave becomes larger, that is, more and more negative. The much studied *b*-wave, after quickly increasing to a maximum becomes smaller as the stimulus increases in size. Immediately after the *b*-wave, there appears a negative wave which is larger than the *a*-wave, but on the average tends to vary with it. This negative after-*b*-wave may be called the *b'*-wave. The course of the change in shape of the ERG with stimulus size is presented in Figure 6 for subject R. H. with the A.C. amplifier and in Figure 7 for subject R. K. with the D.C.

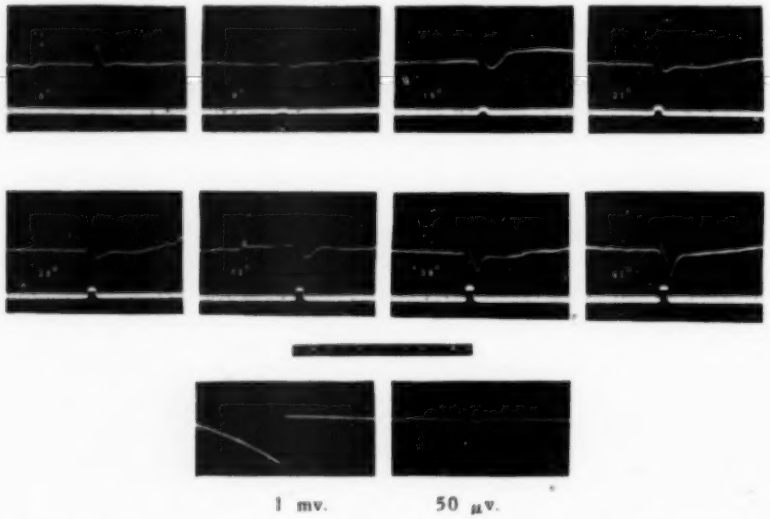


Fig. 6. Series of electroretinograms taken with the A.C. amplifier with increasing stimulus field size from 5° to 41° diameter as marked. Time scale is 5 dots per second. Subject R. H.

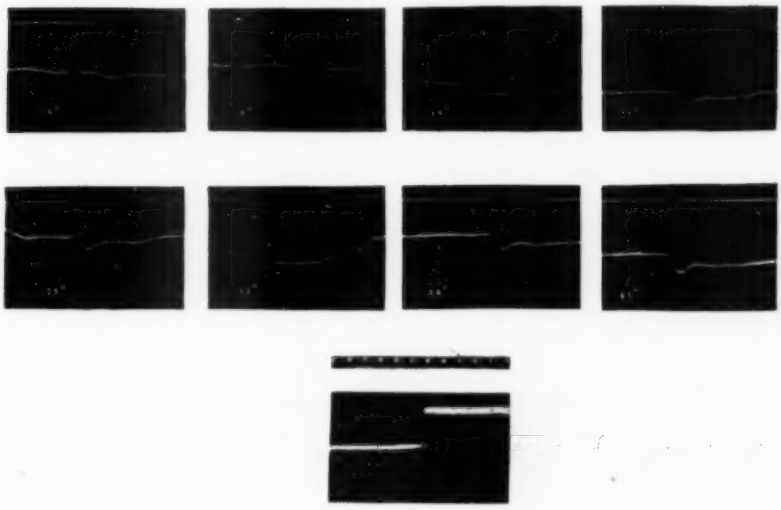


Fig. 7. Same as previous figure except that the records are taken with the D.C. amplifier and the subject is R. K.

amplifier. These are two series of ERG's from the original records which illustrate how the *a*-, *b*-, and *b'*-waves change strikingly with increasing area and constant illuminance.

The height of each wave was measured in microvolts for the two subjects with four runs each. The ERG was determined 10 times for each stimulus size in each run. ERG's for the same stimulus size were averaged. Hence, each point on the curves drawn in Figure 8 is the mean of 80 separate measurements. The course of the negative *a*-wave height with the diameter of the stimulus is seen to be linear except, perhaps, at the extreme ends. The scatter of the points seems to be notably small. The *b*-wave amplitude in this figure exhibits a maximum at about a 9° field and then falls rapidly as the stimulus size is increased.

It is obvious from the graph that the negative after-*b*-wave, or *b'*-wave has a greater scatter than the *b*-wave, and a much greater one than the *a*-wave. However, it is clear that this *b'*-wave, although larger in magnitude, essentially parallels the course of the *a*-wave.

When the same data are plotted as a function of area of stimulus rather than diameter, the curves are somewhat changed. Figure 9 shows

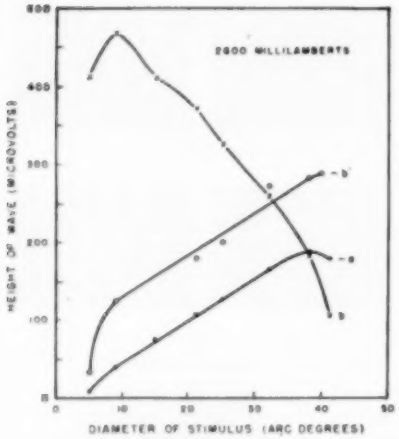


Fig. 8. Mean values of experimental sessions. Note that *a*- and *b'*-waves tend to be parallel linear functions. These two waves are plotted negatively in order to make a more compact graph.

that the *a*-wave plot is no longer linear. Surprisingly, the *b*-wave curve, except for the extreme ends, becomes virtually a straight line. If the data are drawn as a function of the logarithm of the area, both *a*- and *b*-wave plots lose their linearity while the *b'*-wave appears to maintain it, probably because of the greater scatter of the points. In plotting the log area, both *a*- and *b*-waves lose their linear sections as seen in Figure 10.

Let us examine the differences between the two subjects and the

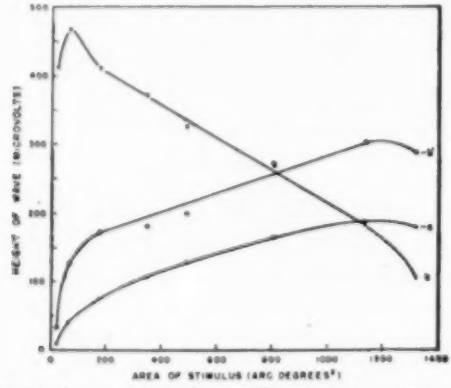


Fig. 9. Replotted data from previous figure. Note that the greater part of the *b*-wave curve appears essentially linear.

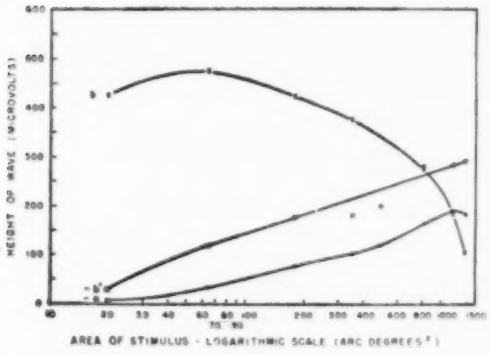


Fig. 10. Replotted data from previous figure.

difference between the electrical methods of obtaining the data. Figures 11, 12 and 13 are plots of the *a*-, *b*- and *b'*-waves respectively of each subject taken with both A.C. and D.C. amplifiers. Each point on the graph represents an average of ten waves. One run was taken with a physiological sodium chloride solution in the contact lens and remote electrode cup instead of the 1½ per cent sodium bicarbonate solution used throughout this experiment.

The D.C. amplifier may limit slightly the fast *a*-wave response because of its limited frequency response. In measuring the *a*-wave amplitudes with the 60 cycle chopper D.C. amplifier the actual peak

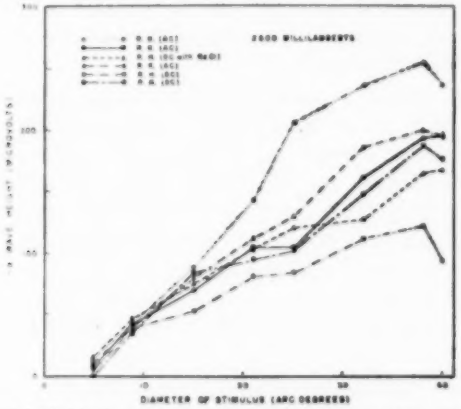
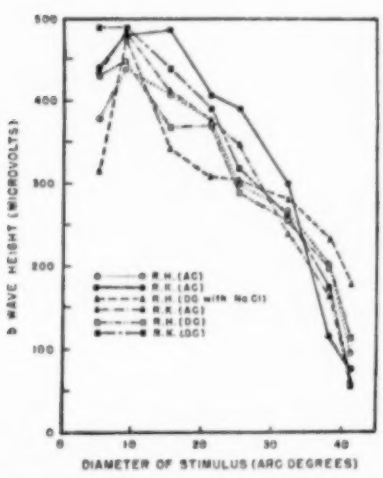


Fig. 11. Plots of individual *a*-wave curves to illustrate possible effects of differences of amplifying system, subjects and electrode fluid. Except where otherwise noted, a 1½ % solution of sodium bicarbonate was used. Each point is the mean of 10 electroretinograms.



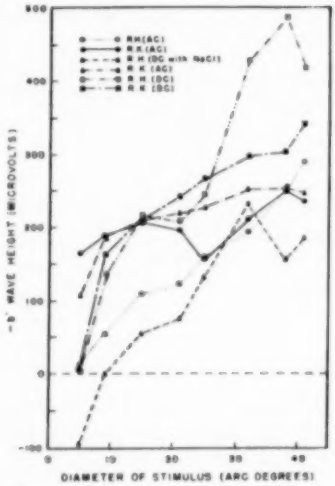


Fig. 12. Plots of *b*-waves, similar to previous figure. (Left.)
Fig. 13. Plots of *b'*-waves, similar to previous figure. (Right.)

of the wave may be located between the dots that trace the wave form. Measurement of the height of a dot then may give a value less than the true one. This is reflected in Figure 11 where it may be seen that the curves taken with the D.C. amplifier are generally somewhat smaller in potential than the curves taken with the A.C. amplifier. This slight reduction of the amplitude of the *a*-wave due to the frequency limitation of the chopper D.C. amplifier does not appear to occur with the slower *b*- and *b'*-waves.

With the exception noted above, there appear to be no obvious differences attributable to the subjects or the type of electrical amplification. The variation appears to be primarily scatter and day to day changes. For example, the two A.C. curves of subject R. K. were recorded in the same experimental run, separated only by the recording of another similar experiment. These two curves tend to be similar throughout the graphs of the three waves.

The stimuli for each curve were presented in order of increasing size with the exception of those used for R. H. (D.C.) which was from large to small.

The 2,600 millilambert stimulus was reduced in logarithmic steps to 260, 26, 2.6 and 0.26 ml. by the filters. Measurements were taken with three stimulus sizes, 15°, 25° and 41°. One run was taken on each subject and the two were averaged to produce the curves shown in

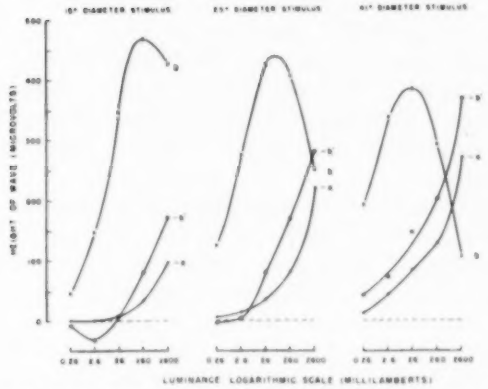


Fig. 14. The effect of stimulus size and luminance on the electroretinogram. Mean values for two subjects. Note that the peak of the *b*-wave curves reduces with larger stimulus diameters. Total luminous flux (area x luminance) at the abscissa under each *b*-wave curve maximum is the same.

Figure 14. Each point, then, is an average of 20 waves. It may be worth noting that the position of the maxima of the *b*-wave curves shifts from about 260 ml. at a 15° stimulus to about 26 ml. at 41°. Within limits of error of measurement, the luminous flux appears to be constant for the position of the maximum of the *b*-wave plot regardless of the size and illuminance of the stimulus. However, the maximum height of the *b*-wave appears to depend on the size of the stimulus.

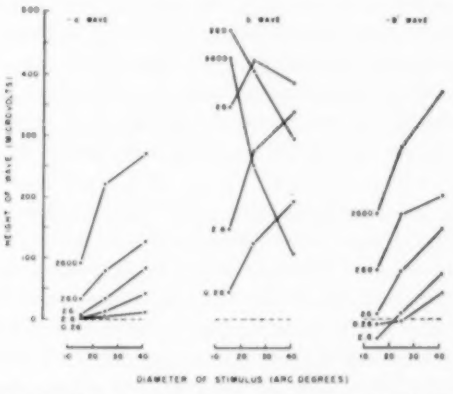


Fig. 15. Replotted data from previous figure illustrating the change of slope of the electroretinogram curves with increasing stimulus luminance. Numerals to the left of each curve indicate the luminance in millilamberts.

The dip of the *b*-wave curve below the base line in Figure 14 is sometimes seen in published curves of the ERG. Often the *b*-wave appears to merge into a *c*-wave without having returned to the base line as seen in Figure 1. In order to relate apparent mergence with the *b*-wave, the after-*b*-wave above the base line was considered as a positive *b'*-wave and so plotted. It appears to show a continuity with the negative *b'*-wave.

The data from Figure 14 were replotted in Figure 15 to illustrate the change of slope of the height of waves and diameter of stimulus curves (Figure 8) by varying the luminance. The *a*-wave plot at 2,600 ml. has a steep, positive slope which decreases with the luminance. The *b'*-wave plot is similar to that of the *a*-wave. The *b*-wave plot has a steep, negative slope at 2,600 ml. It decreases at 260 ml. and is more or less zero in the neighborhood of 26 ml. As the luminance is further reduced, the slope becomes more positive.

CONTROL EXPERIMENTS

Karpe[5a] has shown that a wave resembling the *b'*-wave is produced when the corneal electrode is touched by an air bubble. Extreme care was taken to avoid air bubbles and in spite of this the *b'*-wave could always be obtained.

A stimulus duration of 1/10 second was used throughout the above experiments. The choice of the duration was based on a desire to have a sufficiently long duration in order to obtain a large electrical response and at the same time a concern not to have the duration long enough to interfere seriously with recovery of the retina in the time allowed before the next stimulus was presented. Figure 16 shows the electrical responses as functions of stimulus duration. All responses obviously fall off at durations of less than 1/10 second. The only advantage of longer duration would be the appearance of a strong *c*-wave. However, it was decided not to study this wave at the present time.

With a 1/10 second duration and a maximum stimulus size and retinal illuminance, there must be a certain time or critical duration between stimuli which, if reduced, will not allow recovery of adaptation and associated processes which provide the ERG. It was found that each stimulus presented at a three second interval from the previous one did not appear to be affected; however, the interference was obvious in a reduction of the ERG when the interval was reduced to 1½ seconds. Therefore, the time between stimuli was maintained at about ¾ second and varied between 2 and 5 seconds.

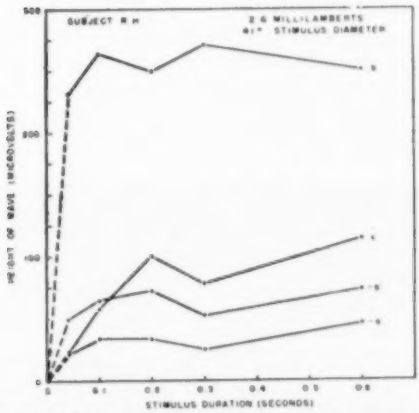


Fig. 16. The effect of stimulus duration on the electroretinogram. The *a*- and *b*-waves are completed within 1/10 second and hence longer stimulus durations would not be expected to affect them. Only the *c*-wave is effectively increased by a duration of more than 1/10 second.

It has often been reported and equally often denied in the literature that light will produce a potential across silver-silver chloride electrodes in a sodium chloride solution. This was tested for the present experiment by mounting the contact lens with its electrode filled with physiological saline at the secondary focus of the stimulus apparatus. The remote electrode was dipped in the same saline and the maximum "stimulus" light was focused on one electrode. No indication of a potential whatever was recorded from this light.

It has been claimed in the literature that there is an electric wave produced, perhaps, as a result of the intraocular musculature. Karpe[5a] has shown that such a wave can be demonstrated with a scleral electrode but is minimized with a corneal electrode, that is, an electrode mounted in a contact lens. Furthermore, this wave which can be recorded from the eye which is not being stimulated, disappears with mydriasis following the application of homatropine. In order to be certain that the electrical response was not being influenced by the pupillo-accommodative mechanism, the left eye was stimulated with the maximum stimulus illuminance and size, and the right eye, shielded from all light, was recorded. There was no response to the stimulus in subject R. K. In subject R. H., however, there was a slow response, amounting to an average of —62 μV. and a mean starting, peak and cessation time of 250, 430 and 750 msec. respectively (Figure 17). The *b*-wave was completed in about 150 msec. with the small stimulus and in

approximately 60 msec. with the large. If the time from the end of the *b*-wave to the peak of the *b'*-wave (50 to 100 msec.) is added to this, one finds that the peak of the *b'*wave from the start of the ERG is about 110 to 250 msec. Hence, the contralateral effect found in this subject apparently was temporally distinct and, therefore, did not interfere with the measurements of the ERG including the *b'*-wave.

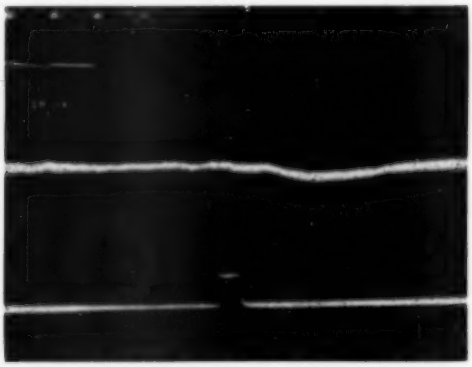


Fig. 17. Small, slow electrical response of subject R. H. to the maximum stimulation of the contralateral eye. Subject R. K. exhibited no response at all under the same conditions.

A control experiment was made with subject R. H. after instilling homatropine and awaiting the mydriasis and the paralysis of accommodation. Substantially the same results were obtained. This is further evidence that neither possible action of the ciliary muscle nor movement of the iris appear to affect the curves previously measured. The pupil, conceivably, could have momentarily constricted to less than the 5 mm. diameter of the beam of light entering the eye. The results with the pupil widely dilated by homatropine do not indicate any noticeable effect from this potential source of error.

The most difficult of all control experiments concerned the holding of the lids to try to determine whether lid motion was responsible for the *b'*-wave. Quantitative measurements were not practicable because fingers on the lids disturbed the base line of the recording. Furthermore there was scarcely enough room for the fingers between the eye and the eyepiece of the stimulus apparatus. The *b*-wave was obtained while the lids were held which indicates that lid movement is not responsible, but these movements may not have been completely eliminated. The *b'*-wave has the same polarity as the electrical pulse resulting from a blink as may be seen in the 32° field record of Figure 7.

It might be thought that the relatively frequent flashes cause enough light adaptation to play a part in the production of the *b'*-wave. It was found, however, that the *b'*-wave occurred as a result of the first stimulus presented after 25 minutes of dark adaptation. Because of the multiple stimuli presented, the state of dark adaptation was certainly not maximal during the course of the experiment. However, it does not appear that the results were affected by the level of adaptation of the eye.

DISCUSSION AND CONCLUSIONS

One of the reasons for using the less convenient D.C. amplifier was to learn if electrode polarization had distorted the records obtained with the A.C. amplifier. It has been shown that polarization is of no consequence if the current density of electrodes does not exceed one microampere per square centimeter at the electrode surfaces in physiological saline solution.[6] The D.C. amplifier was operated from a zero point of no current flow. The actual flow during the ERG was negligible and polarization was not a likely problem. With the A.C. amplifier, the battery box was not used to provide a null reference and the limiting current density mentioned above was sometimes exceeded. However, no difference was found in the records from the two systems of amplifiers which indicated that polarization was no more serious with the A.C. than with the D.C. system even when sodium bicarbonate was used for the electrode fluid.

Fry and Bartley[7] have shown that the ERG as commonly taken with a small field is a nonfocal ERG, rather than focal. In other words, scattered light within the eye over the large retinal area is the cause of the ERG rather than the focused light over a small circumscribed retinal area of a few degrees. Boynton and Riggs[4f] and also Asher[8] have confirmed this finding by showing that the ERG produced by a beam of light whose focus is confined to the optic nerve head gives the same ERG as the same beam does on the retina. Fry and Bartley theorize that there are actually two separate ERG's, the focal *b*-wave being larger with a shorter latent period than the nonfocal *b*-wave. They believe that with a large enough focal area, the two *b*-waves may be resolved into a bimodal *b*-wave. No bimodal curve was found under the conditions of this experiment. However, evidence was found for the change of relative contributions of the focal and nonfocal *b*-waves in Figure 14. As already mentioned, the position of the maxima appears to depend on a constant luminous flux regardless of the size of the field. However, the height of the maxima clearly depends on

the size of the stimulus. The effect of area on the ERG with a constant flux and therefore presumably constant scattering appears to be demonstrated. The fact that the height of the maxima of the *b*-wave curves decreases with increasing area may be attributed to the inhibition of the *b*-wave or the stimulation of the *a*-wave with area.

It has been hypothesized in terms of processes proposed by Einthoven and Jolly[1] and exhaustively investigated by Granit[2] and others, that as P III, which essentially causes the *a*-wave, increases negatively with increasing stimulus, the effect of P II, which essentially causes the *b*-wave, is progressively reduced. One could further hypothesize that as the stimulus is increased, P III becomes more negative and its termination is no longer masked by P II but extends beyond the *b*-wave. This would provide a negative after-*b*-wave which has been demonstrated here and called *b'*. The fact that the *b'*-wave tends to parallel the *a*-wave is evidence for this hypothesis.

Parry, Tansley and Thomson[9] have reported a negative after-*b*-wave in the dog which persisted after severing the optic nerve. The light reflex pathway to the pupil was interrupted and therefore this reflex could not have generated the wave. This after-*b*-wave appears to be the same phenomenon demonstrated here in man.

SUMMARY

The human electroretinogram (ERG) was measured with the aid of an electrode mounted in a contact lens. Measurements were made with an A.C. amplifier and a cathode ray oscilloscope and camera. Possible distortions of the A.C. amplifier were evaluated by remeasuring the potentials with a unique, sensitive and stable D.C. chopper (converter) amplifier system.

The human ERG was produced by a stimulus of one-tenth second duration, provided by a "Maxwellian view" of the optical system. Stimulus sizes were from 5° to 41° and luminance up to 2,600 millilamberts. Curves illustrate the course of the *a*-wave and *b*-wave. Of interest is the emergence of a negative wave immediately after the *b*-wave which may be a part of the retinal illumination potential.

Evidence is presented for a change in the relative contributions of the nonfocal and focal ERG's as the stimulus is varied in size and luminance.

Acknowledgment is gratefully made to Mr. Edward J. Correll for his suggestions and aid with the electronic apparatus. The patient services of Lieutenants Richard Hogan and Roderick Kelley as subjects are also acknowledged.

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SILENCE AS TACIT CONSENT*

The writer read with great interest Part I of the special report, "Problems with Dispensing Opticians: Improper Promotional Activities," by Carel C. Koch which appeared in the June, 1953, issue of the JOURNAL. I particularly liked the objectivity and fairness of the report, and the directness with which it spared neither optometry nor opticianry nor ophthalmology in enumerating about every possible source of friction that has arisen or could arise between these various groups.

In Koch's account of the major source of friction between

*By Eugene Freeman, Optometrist, Ph.D. Fellow, American Academy of Optometry, Vice-President and Dean, Chicago College of Optometry, Chicago, Illinois.

optometry and opticianry, he is quite correct in condemning the dual activity of many dispensing opticians for (A) their misleading advertising which publicly disparages the optometrist's professional status and ability, and (B) their conduct in serving as "steerers and cappers" for delivering patients, by collusion, to certain ophthalmologists' offices.

On my first reading of the paragraph in which the above point is made (4th paragraph, page 321) I wondered whether or not the term "collusion" which Koch used might not have been too strong a term, inasmuch as I have no doubt that many patients are delivered to ophthalmologists' offices entirely on the initiative of the optician. On considered reflection, however, it occurred to me that whether or not there was an active collusion between an ophthalmologist and an optician in any individual case, that unquestionably there is at least a passive collusion between the entire profession of ophthalmology and the whole field of opticianry. This passive collusion makes the profession of ophthalmology a party to both of the practices of opticianry which Koch condemns, namely the disparaging advertising, and the improper steering of patients. The code of ethics of the ophthalmologist would prohibit him from actively either (A) making disparaging remarks about fellow professional practitioners through any medium of communications, or (B) employing an agent to steer patients into his office. There is no possible doubt that ophthalmology is fully aware that opticianry is carrying on these practices in order to gain the approval and good will of ophthalmology. If the ophthalmologist were to *condemn* these practices, the optician would undoubtedly desist. By not condemning these practices, ophthalmology gives its tacit consent to them and thereby—in a passive way, to be sure, but nevertheless very effectively—participates in and shares the responsibility for this unprofessional conduct.

I feel, therefore, that the ophthalmologist must recognize his full responsibility in this matter. Instead of passively consenting to let the optician perform for the ophthalmologist "services" which would have been clearly and grossly unprofessional had the ophthalmologist performed them for himself, ophthalmology must take an active position.

Ophthalmology must point out to opticianry that it disapproves of any practices carried on by opticianry for ophthalmology which could not be actively endorsed by ophthalmologists without making the latter guilty of unprofessional conduct. The condemned practices would include (A) misleading or false advertising which holds out that only

M.D.'s are qualified to do refractions, and (B) steering patients to selected ophthalmologists with whom they have accounts.

EUGENE FREEMAN

SUBSCRIBE NOW TO THE SHEARD COMMEMORATIVE VOLUME FUND*

As a friend of Sheard I was happy to accept the assignment of Academy President Meredith W. Morgan, Jr., to serve on the SHEARD COMMEMORATIVE VOLUME COMMITTEE.

Nineteen fifty three marks the FIFTIETH ANNIVERSARY of Dr. Sheard's entrance into optics and optometry. Also in 1953 he joined the ranks of the septuagenarians. However, these were not the prime reasons for the unanimous decision of the Executive Council of the Academy to honor Dr. Sheard at this time.

Far more important than the passage of the years have been his contributions to the advancement of optometry. His early grasp of the fundamental importance of *Dynamic Ocular Tests* laid the foundation for the transformation of optometry from the static profession mainly concerned with the correction of "errors of refraction" into a new dynamic optometry interested in the entire seeing complex: physical, physiological and psychological with all possible interrelations of these and other factors.

He travelled the length and breadth of this country and abroad, giving to the men in the field their first insight into this new concept. At the Ohio State University he inaugurated the program of research in the relationship of accommodation and convergence which is continuing under the genial and expert direction of Dr. Glenn Fry.

Dr. Sheard may well be regarded as the "optometric godfather" of the whole line of brilliant visual scientists who have emerged from that institution: Fry, Knox, Hofstetter, Ellerbrock, Stewart, Knoll, Allen, Alpern, *et al*, to say nothing about the hundreds of graduates of that and other institutions all of which have followed suit and converted a revolutionary idea into routine daily practice.

The COMMEMORATIVE VOLUME will serve the double purpose of honoring Dr. Sheard and bringing together into one well printed, cloth bound book of 300/400 pages: ESSAYS on OCULAR CONVERGENCE and ACCOMMODATION—DYNAMIC OCULAR TESTS—DYNAMIC SKIAMETRY —OPHTHALMIC OPTICS and other contributions on BINOCULAR VISION

*By Ernest A. Hutchinson, President Emeritus, Los Angeles College of Optometry. Los Angeles, California. Fellow, American Academy of Optometry.

by Charles Sheard, Ph.D., Sc.D., O.D., which should find a place in the library of every optometrist and in the hands of every student of optometry. All readers should now subscribe.

While it is hoped that many will subscribe $25.00 towards the estimated cost of $8,000.00, as little as $10.00 will insure to the subscriber his own individual copy with his name printed in the book as a friend of Sheard who helped make the text possible. Send your check now to Dr. Carel C. Koch, Secretary, American Academy of Optometry, 1502 Foshay Tower, Minneapolis 2, Minn. Immediate action will aid the Committee in deciding how many copies to have printed.

ERNEST A. HUTCHINSON

VISUAL SCIENCE IN THE MAKING*

The June, 1953, issue of the JOURNAL OF THE OPTICAL SOCIETY OF AMERICA contains nine research articles that may well be considered within the visual science interest of optometrists, as follows:

Effectiveness of Red Light on Dark Adaptation
Stray Light and the Human Electroretinogram
Electrical Responses of the Light-Adapted Eye
Studies of the Form of Visual Threshold Data
Factors Affecting Differences in Apparent Size Between Opposite Halves of a Visual Meridian
Aniseikonia and the Howard-Dolman Test
Perception of Color in 1° Fields for Different States of Adaptation
Spectral Sensitivity of the Fovea. I. Neutral Adaptation.
Disappearance of Steadily Fixated Visual Test Objects

This happens to be more than the usual proportion of J. O. S. A. articles in the areas of research conventionally thought of as basic to the optometric sciences. The usual monthly issue carries only one or two articles that come so close to our professional interests. In the course of a year, however, these accumulate to a substantial amount of material that provides stimulating and informative reading for the optometrist who is at heart a student of science. Rarely an optometrist may have some interest in the many other J.O.S.A. articles that relate to colorimetry, spectroscopy, optical instruments, physics of light, photographic optics, etc., but even with all such peripheral interests excluded, this Journal should appeal to many more optometrists than may even be aware of its existence.

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*By Henry W. Hofstetter, Optometrist, Ph.D. Fellow, American Academy of Optometry. Director, Division of Optometry, Indiana University, Bloomington, Indiana.

A significant share of the information disseminated in the current courses of the optometry schools has been and continues to be derived from the periodical research reports of this publication. Staff members of optometry schools occasionally publish their research reports here. Dr. Glenn A. Fry of the Ohio State University School of Optometry has been one of its Associate Editors for several years. It frequently runs reviews of books of optometric interest; in the aforementioned June issue, for example, a book on ophthalmic optics is reviewed by Mathew Alpern of the Pacific University, College of Optometry.

The AMERICAN JOURNAL OF OPTOMETRY would be remiss in its professional obligations if it did not occasionally call to the attention of its optometric readers the otherwise unheralded contributions of a scientific periodical so outstanding as the JOURNAL OF THE OPTICAL SOCIETY OF AMERICA.

HENRY W. HOFSTETTER

SPECIAL REPORT

PROBLEMS WITH DISPENSING OPTICIANS*

PART II—THE REFERRAL QUESTION

Carel C. Koch†
Minneapolis, Minnesota

INTRODUCTION

This proposal deals with three related items. These are (1) the suggestion that steps be taken to eliminate business touting for medical refractionists by some dispensing opticians wherever this practice occurs: (2) that steps be taken to eliminate discriminating practices against optometrists now engaged in by some dispensing opticians and (3) to assure dispensing opticians that if they discontinue these discriminating practices against optometrists and refer refractive cases to optometrists as well as ophthalmologists on a free choice of doctor basis, optometrists and ophthalmologists will, in turn, return these referred cases back to the optician for glasses when these are required by the patient.

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*Submitted on April 20, 1953, for publication in the August, 1953, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry.

BACKGROUND

Part I‡ of this proposal to optometry, ophthalmology, opticianry and to the National Interprofessional Committee on Eye Care dealt with certain very questionable promotional activities of many dispensing opticians which were causing friction between optometry and dispensing opticians. One of the points at issue was the discriminatory advertising of some dispensing opticians in which only medical refractionists were recommended by opticians to the public for refractive work. In Part I it was suggested that at local levels in those areas in which the trouble existed, the leadership of all groups meet and confer with the Better Business Bureau officials and the advertising representatives of the newspapers, radio and television stations. As a result of these conferences, *Standards of Practices* could be worked out to eliminate or at least minimize these causes for friction.

The writer believes that in many localities this could be accomplished successfully, particularly if the program had the backing and support of the parent bodies whose representatives are members of the National Interprofessional Committee on Eye Care. A list of members appeared in the June, 1953, issue of the JOURNAL, page 319, along with the organizations represented on the committee.

This second portion of the report deals with the problem of certain dispensing opticians serving as business touters for certain favored ophthalmologists, oculists and E. E. N. & T. men. This practice is also a cause of friction between those working in the field of eye care. The practice occurs in many urban centers. In some places it is carried on rather blatantly with an almost complete disregard for professional niceties. In other instances, it is carried on with more finesse in what might be termed a surreptitious manner, but in either event the problem exists, and it has a serious detrimental effect upon interprofessional relations.

It must be pointed out here that all ophthalmologists are not involved in this practice. In fact, the majority of these physicians have nothing to do with it. These men frown upon the practice and do not encourage it. It is to these men that the committee must turn if this major cause of friction is to be eliminated. These ethical physicians, through the power they possess as medical leaders, can, if they wish, bring the activity of business touting by opticians to an end.

This is not a problem, however, which lends itself to an easy solution. There is a major element of dollar economics involved which

‡Part I of this report, "Improper Promotional Activities," appeared in the June issue.

seems at times to overshadow the ethical concepts which are violated by the practice. It is a problem which must first be approached through medicine as that group is the one involved which could most easily understand optometry's position in resenting the activities of some optical dispensers who engage in the practice of business touting for some medical refractionists, while at the same time refusing to recognize the capabilities of modern day optometrists.

For a considerable number of years all optometrists, without exception have had at least four years of college training. Since 1947 they all have had five years of specialized work, and just recently one of our colleges has announced that it is going on a six-year basis. This educational advancement in excellent schools and colleges assures the public and the professions that well trained men are in the field practicing as optometrists.

To give the committee and representatives of all groups the proper perspective of the entire question, the writer must first point out that most optometric licensing and regulatory laws prohibit the optometrist from any acts which might be considered misleading or harmful to the public. These laws exist in every state. This is as it should be, and organized optometry is doing everything in its power to strengthen these laws in this regard in the public's interest. These laws have already limited the possible promotional activities of all optometrists—more so, to be sure, in some states than others. These laws will be improved by amendments in the future as it is evident that in the field of health care such promotional activities are not in the public's best interest.

In addition, organized optometry has, through its Rules of Practice and its Code of Ethics, set up high standards of practice which are now being followed by a very great body of optometrists. These rules of practice are similar to those of medicine and dentistry and prohibit the optometrist from many promotional activities including advertising. They also prohibit the optometrist from employing steerers and cappers to solicit business for him. In other words, in optometry its laws, and rules of practice, and its code of ethics prohibit the optometrist from using certain "business stimulants" which experience has found to be misleading and harmful to the public.

As a professional group, optometrists understand the need for these standards and expect all members of their professional societies to abide by them. Violations of ethical standards, when these occur, in optometry are corrected as rapidly as possible under existing legislation. Violaters are dropped or barred from association membership unless

they abstain from such improper conduct. These ethical standards are high, and are making themselves felt in the growing recognition accorded to optometrists by educators and professional people everywhere.

It is to medicine first—in this instance the representatives of ophthalmological sections and societies—that optometry must turn with the problems presented in this proposal. It is to the official family of ophthalmological groups represented on the National Interprofessional Committee on Eye Care that we must appeal to correct the situations which exist and which are causing so much ill feeling, and which in themselves are doing much to discredit all those serving the public in the field of eye care.

We must next appeal to organized groups of opticians to help correct these practices in their own interest as the public is becoming aware of the misleading propaganda and of this traffic in patients with the national resentment which would normally accompany this. This resentment is directed, not only at the offenders, but at all ophthalmologists, optometrists and opticians as the public has difficulty in always recognizing those who are guilty from those who are innocent. The repercussions on a national scale of the "kick-back" scandal involving some opticians and eye doctors are still too familiar to us all to enable us to forget this obvious fact.

No doubt ophthalmological organizations already have, in their codes of ethics, prohibitions against their members entering into collusive agreements with lay-persons or dispensing opticians which would cover the situation. If not, they can in good faith be adopted and made part of the record. If already on the books, they can be enforced. State medical societies will support such a move, the writer believes, particularly if it is vigorously implemented by action on the part of State Academies of Ophthalmology.

Would anyone suffer from such a move? Only perhaps those favored refractionists who are today receiving the bulk of referrals from the dispensing opticians under discussion. The great body of eye men would benefit, as they are not now involved in such arrangements and would logically receive more chance routine referrals than at present. Certainly dispensing opticians would not suffer. Their business should, in fact, be better as relations would be vastly improved with a much larger group of refractionists than at present.

THE SUGGESTIONS

The writer wishes to propose to the National Interprofessional

Committee on Eye Care, and to the parent bodies represented by the committee, that in the interest of better professional relations, and also better public relations for those in the field of eye care, that it consider the following suggestions and that it approve these and refer same to the parent bodies of the committee.

(1) That ophthalmological and opticianry organizations take those necessary and appropriate steps to eliminate, wherever found, the practice of business touting for certain favored ophthalmologists, oculists or E. E. N. & T. men by those dispensing opticians who engage in this practice.

(2) That it be recommended to our parent bodies that in all cases dispensing opticians refer prospective refractive patients to ophthalmologists or optometrists without discrimination as to the type of refractionists practice.

That we, as a committee, recognize this discrimination as a source of friction between ophthalmology, optometry and opticianry and that we urge all dispensing opticians to refrain from this practice. The patient seeking refractive care should have a free choice of doctor.

(3) That in cases referred to ophthalmologists or optometrists by dispensing opticians that the patient be promptly returned, where possible, to the dispensing optician to have the prescription filled if ophthalmic materials are needed by the patient.

DISCUSSION

The adoption of these suggestions would remove one of the major causes of friction between optometry and opticianry. It would improve the tone of all practice in the field of eye care, and would eliminate those doubtful questions which are in the public mind regarding those doing refractive work.

At the present time, both ophthalmology and optometry fail to enjoy the high public confidence due us, largely because of the highly unethical conduct of minorities in each group, and because of the very questionable promotional activities of some optical dispensers.

The adoption of these suggestions would also eliminate those punative court actions against dispensing opticians by local groups of optometrists. These actions have been very costly to opticians. It would also eliminate those possible legislative attempts in the future against those same practices. Opticianry may be sure that optometrists are too busy with their own affairs to be concerned with legislation relating to opticianry unless they are driven to it by improper activities on the part of some opticians.

The National Interprofessional Committee on Eye Care has a unique opportunity to render an outstanding service to the public and to all ophthalmologists, optometrists and opticians in taking the lead in bringing these troublesome problems to an end. The writer is sure that optometry will do its part in cooperation with the others on the committee, and in addition he can assure those in ophthalmology and opticianry that the professional leadership in optometry is pledged, with the professions full support, to eliminate those unethical practices which still exist among optometrists in certain areas.

If ophthalmology wants good relations with optometry in the public's interest, now is the time to consider these important matters. Ophthalmology can easily control the activities of dispensing opticians. These dispensers exist chiefly as ancillary aids to ophthalmologists and certainly these dispensers would respond to the wishes of organized ophthalmology if the request was made by the parent bodies and supported by local academies.

Optometrists, at the local level, have evidenced their displeasure towards these activities on the part of some dispensing opticians by means of lawsuits and legislative attempts to correct these abuses. It is a matter of record that these local attempts to correct the problems are becoming more frequent.

During the same period, we have, at the national level, assured opticians of our good intentions towards them and the work they do by an official resolution on the part of the American Optometric Association, and through our Rules of Practice which eliminates the optometrist from the general dispensing field. We have hoped by these actions at the national level that organized opticianry would voluntarily start to clean house, or at least attempt to do so. In this, they have significantly failed.

As the National Interprofessional Committee on Eye Care goes into its fourth year, perhaps this is the time to have it consider the questions and problems presented by the writer in Part I and Part II of this report. Perhaps this is also the time to have the committee throw its weight and its influence behind those ideals which stand for the right and proper practices in the field of eye care so that the public can be better served by all men in ophthalmic optics.

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

A JOB FOR OUR STATE BOARDS

Just how far should State Boards of Examiners in Optometry go in protecting the public from improper acts on the part of optometrists—acts which may be very harmful to patients? This thought is raised by Morris[1] in a recent report dealing with optometrists' professional fees. Morris believes that our State Boards are charged in the public's behalf to rigidly curtail the activities of "quickie" refractionists. These are usually optometrists in commercial surroundings who admit they plan to complete the entire examination and refraction in not more than 10 minutes.

As individual practitioners, optometrists resent meticulous regulation by State agencies, but there are times when such supervision becomes necessary. While the number of offenders is small in relation to the total number of optometrists in practice, the offenders, it must be realized, are, in securing their patients, trading upon the already excellent reputation of ethical optometrists. If it were not for the great group of optometrists who practice properly, the offenders would have no standing with the public at all and would, therefore, have little or no opportunity to practice as optometrists.

In addition, the unsuspecting and uninformed public as potential patients have no method of knowing the conscientious men from others and so later, as patients, certain individuals are occasionally tricked into securing what they believe to be an adequate examination and refraction at the hands of a "quickie" refractionist when, in reality, what they got was a poor hit-or-miss substitute.

The trouble here is that the patient who has had this experience frequently goes on his way trusting and believing that everything is satisfactory as far as his eyes are concerned when, in reality, one or more major problems may have been overlooked in the rush to sell glasses to the victim. This is where the harm comes in—and it is around this important point that our State Boards of Examiners in Optometry should step in with appropriate action.

[1] C. W. Morris. The Perennial Problem in Optometry. Optical Journal and Review of Optometry. Vol. XC., No. 12, pp. 33-37. June 15, 1953.

It is not necessary for a State Licensing Board to show actual injury to a specific patient as the result of one of these "quickie" refractions. All that is needed is for the Board to have evidence that it is common practice for refractions to be made in this manner by such an offender. The substantiated evidence secured with a stop-watch by a trained observer should be sufficient. Other expert testimony can easily be had to support the Board's contention that no series of diagnostic and refractive tests covering all necessary steps of an examination and refraction can be made in 10 minutes. Our State Board members know this. Refractions performed in this short time must of necessity omit many essential and valued techniques. Yet these "quickie" refractions leave some patients with a feeling of security which such slipshod work should not justify, and which cannot be defended.

It is around this point that our State Boards should take action in the public's behalf, and thus make it impossible for these offenders to continue. A few suspended licenses for these "quickie" refractionists is all that is necessary to bring about a needed reform which is long overdue. The time for our State Boards to act on this problem is now!

CAMPUS NEWS

Dr. Charles Stewart, Dean, College of Optometry, University of Houston, announces that the college laboratories will be in the new wing of the Science Building, on or about December 1, 1953.

Senior students at the Northern Illinois College of Optometry heard a series of lectures prior to graduation in June. The speakers and their subjects were, Dr. Don A. Frantz, DeKalb, Illinois, "Building a Successful Optometric Practice"; Dr. Leo Manus, Chicago, Illinois, "Visual Training"; Dr. H. E. Lang, Highland Park, Illinois, "Optometric Organizations"; Dr. Carl W. Lange, St. Louis, Missouri, "Visual Training with the Lange Coordinator"; Dr. Otis Wolfe, Marshalltown, Iowa, "Childrens Cataracts"; Dr. Richard Feinberg, President of the College, "Occupational Vision"; Dr. Carl Shepard, Director of Research at the College, "Fee Systems," and Mr. Michael C. O'Hara, Univis Lens Company, Dayton, Ohio, "Trifocal and Multifocal Lenses."

The Anniversary issue of the NICO Alumnus magazine is now available for general distribution. The magazine traces the history of the College and contains many pictures, anecdotes and stories about the students and organizations. Copies may be obtained from the Executive Secretary, Alumni Association, Northern Illinois College of Optometry, 830 East 42nd Place, Chicago 15, Illinois at 50c each.

Massachusetts College of Optometry has launched a $100,000 Building Fund drive among its alumni and friends. President of the College, Dr. Joseph F. Montminy is heading the campaign. All New England optometrists are urged to contribute.

Dr. Rudolph Ehrenberg, Granite Falls, Minnesota, President, National Board of Examiners in Optometry, will present a series of talks as visiting lecturer, on the Clinical Correction of Aniseikonia, at the Chicago College of Optometry during the Fall Quarter.

The College of Optometry, Pacific University, is furnishing the clinical eye services for a group of retarded readers being trained on the campus during the summer months.

The annual reunion of the University of California School of Optometry Alumni Association will be held October 24, 25 and 26, on the Berkeley campus. The program devoted to education and enjoyment will feature four outstanding speakers and the traditional U. S. C. California football game in the U. C. Memorial Stadium on Saturday, October 24. A block of tickets is available for the game so that the optometrists and their wives (or guests) may sit together. The main educational sessions, on Sunday, will be addressed by Frederick C. Cordes, M.D., Chairman of the Division of Ophthalmology of the U. C. School of Medicine, and a member of the National Interprofessional Committee on Eye Care; Guy T. Buswell, Ph.D., Professor of Education at U. C. and one of the nation's leading authorities on vision in reading problems; Meredith W. Morgan, Ph.D., Professor of Physiological Optics and Optometry at U. C. S. O., and the President of the American Academy of Optometry; and Elwin Marg, Ph.D., Assistant Professor of Optometry at U. C. S. O. who has just returned to the school after spending two years directing research for the United States Air Force. Seminars in contact lens fitting and in orthoptics will be conducted Saturday morning and on Monday, October 26. These seminars will be an excellent opportunity for returning graduates to discuss their own ideas and methods and to learn of recent developments in these two fields.

ACADEMY MEN IN THE NEWS

Dr. John E. Martin, Carroll, Iowa, has just been appointed to a three-year term on the Iowa Board of Examiners in Optometry by Gov. William S. Beardsley.

Dr. Julius Neumueller of the faculty of the Pennsylvania State College of Optometry has been spending the summer in Europe.

Dr. Monroe J. Hirsch for the past four years professor of optometry in charge of post-graduate education and research at the Los Angeles

College of Optometry, has announced that he will establish an office for the private practice of optometry in Ojai, California. (P. O. Box 367.)

Dr. Richard Feinberg, President, Northern Illinois College of Optometry was one of the speakers at the annual meeting of the Montana Optometric Association, August 1-3, at Butte.

Dr. Harold M. Fisher, New York City, Past President of the American Academy of Optometry, was elected President of the New York State Optometric Association at its annual meeting in Rochester, New York, June 19-21. Dr. Fisher is a member of the faculty of the School of Optometry, Columbia University, New York City.

Dr. Walker H. Matthews, Athens, Georgia, was re-elected President of the Alumni Association of the Northern Illinois College of Optometry at its annual meeting in Rochester, New York, June 22.

Dr. Gerald Westheimer, formerly of the Ohio State University, Columbus, Ohio, has joined the faculty of the College of Optometry, University of Houston, Houston, Texas. Dr. Westheimer received his Ph.D. degree in the spring of this year.

SASKATCHEWAN REFRESHER COURSE

The 20th annual Refresher Course of the Saskatchewan Optometric Association was held at the University of Saskatchewan, Saskatoon, Canada, May 25-29. The lecturers were, Dr. G. J. Millar, Associate Professor of Physiology, University of Saskatchewan, who spoke on the neurology of vision. Dr. J. E. Newell, Assistant Professor of Pathology who spoke on ocular pathology and Dr. Edward J. Fisher, Dean of the Ontario College of Optometry, Toronto, who spoke on the refractive problems of children.

DEPARTMENT OF PUBLIC INFORMATION—A.O.A.

Dr. Elmer M. Soles, Pittsburgh, Pennsylvania, Director of the Department of Public Information of the American Optometric Association announces a new folder "Teachers Guide to Vision Problems," for use during the coming school term. The folder lists the symptoms which may indicate a visual problem on the part of the student. The folders may be secured in quantity for $3 a hundred. The Department has also prepared an outline of 79 other similar public relations aids which it has available and which may be purchased through State Optometric Association Secretaries. State Association officials may also secure copies of the report presented by Dr. Soles at the recent A.O.A. Congress at Rochester, New York.

VISION RESEARCH CONFERENCE AT OHIO STATE UNIVERSITY

The 10th annual conference on Vision was held at The Ohio State

University, Columbus, Ohio, June 17-18. Dr. Samuel Renshaw presided. The following papers were presented: Dr. S. Howard Bartley, "The Relation of Vision, Touch and Kinaesthesis in a Space World"; Dr. C. S. Bridgman, "The Analysis of Intermediate Luminosity Curves"; Dr. K. T. Brown, "Rate of Perceptual Change of an Ambiguous Figure as a Function of Inspection Time"; Dr. J. Bruell, "Relation Between Retinal and Muscular Factors in Egocentric Localization"; Dr. W. J. Crozier, "On Seeing Frequencies and Incremental Intensity Thresholds"; Dr. F. L. Dimmick, "A Method of Determining Small Differences in Dark Adaptation"; Dr. P. M. Fitts, "Studies of Stimulus-Response Compatibility"; Dr. W. F. Grether, "Demonstration of a new Visual Photometer for Small Targets at Low Brightness"; Dr. S. K. Guth, "Brightness Difference—A Basic Factor in Seeing"; Dr. W. C. Halstead, "Some Behavioral Effects of Bilateral Adrenalectomy in Man"; Dr. I. G. H. Ishak, "The Relative Contributions of Disparity and Convergence to Stereoscopic Vision"; Dr. D. B. Judd, "Entoptic Color Perceptions of the Macular Pigment by Observers of Normal and Color Defective Vision According to the Three Component Theory"; Dr. H. W. Liebowitz, "The Functional Significance of Dual Sensory Localization in the Visual Cortex"; Dr. F. A. Mote, "Dark Adaptation After Intermittent and Continuous Pre-Exposure of Equal Duration"; Dr. S. M. Newhall, "Color Perception in Small Test Fields"; Drs. S. Renshaw, R. Laymon and W. Hobarth, "Three Further Studies of Size Constancy"; Dr. Gordon L. Walls, "Some Improvements (?) of the Three Component Color Theory," and "The Filling-in Hypothesis"; Dr. Gerald Westheimer, "An Analysis of Eye Movements in the Horizontal Plane"; Dr. S. E. Wirt, "Some Variations of the Wallach Cone with Stereoscopic Effect"; Dr. E. Wolf, "Critical Flicker Frequency in Relation to Size and Retinal Location of Test Field."

WORSHIPFUL COMPANY OF SPECTACLE MAKERS

The Worshipful Company of Spectacle Makers of London, England, is one of several large examining and certifying bodies for the optometrists of the British Empire. On June 22, the Master of the Worshipful Company, (Chartered in 1629), Mr. Walter L. Chance, M.A., J.P., accompanied by the two Wardens, presented diplomas in Apothecaries' Hall to 17 candidates who were successful in the final examination of the Company last January.

After the presentation of diplomas, Mr. Francis Slade, the Honorary Secretary of the Victorian Optical Association, handed over to the

Master the first diploma in Visual Optics to be issued by the Company nearly 55 years ago. This was gained by the late Mr. Carl Werner of Ballarat, Victoria, Australia in 1898. It is numbered #1, and after being in Australia since its first presentation it is now being returned to the Company by the Australian College of Optometry, Melbourne, at the request of the Werner family. Mr. Carl Werner died 18 years ago, but his three sons, who are all diploma holders of the Company, still carry on the family practice at 336 Collins St., Melbourne, Australia. Mr. Roland Champness is Clerk of the Worshipful Company of Spectacle Makers in London.

AMERICAN OPTOMETRIC FOUNDATION

Dr. William C. Ezell, Spartanburg, South Carolina, was re-elected President of the American Optometric Foundation at its annual meeting in Rochester, New York, June 23. Others elected were, Dr. Roy E. Denny, Indianapolis, Indiana, First Vice-President: Dr. Roger O. Lindquist, Minneapolis, Minnesota, Second Vice-President: Dr. Joe M. Ashmore, Spartanburg, South Carolina, Secretary: Dr. Adelbert O. Parrott, Fall River, Massachusetts, Treasurer. Dr. Harold V. Hutcheson, Tarrytown, New York, Dr. Kenneth E. Thayer, Fayette, Missouri, and Dr. Herbert L. Kent, Fresno, California, were elected Directors.

Continuations in grants-in-aid were made to Dr. Neal J. Bailey, The Ohio State University: Dr. Darrell B. Carter, University of California: Dr. Alfred A. Rosenbloom, Jr., University of Chicago: Dr. Merton C. Flom, University of California, and Dr. Gordon G. Heath, University of California, during the sessions of the Foundation.

NOTE ON COMING ACADEMY MEETING

Dr. John D. Perry, Jr., Winston-Salem, North Carolina, Vice-President of the Academy and Chairman of the Papers and Program Committee, announces that the committee is making splendid progress in arranging the program for the coming meeting of the Academy at Chicago, Illinois, December 5-6-7-8, 1953. Outlines of all papers to be presented at this meeting should be in the committee's hands on or before October 1, to permit scheduling for presentation at the four day sessions which will be held at the famous Drake Hotel. Academy members, too, should now start their planning to attend this annual session of the Academy.

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data news, professional problems and ideals, as these relate to the Academy.

SHEARD COMMEMORATIVE VOLUME COMMITTEE

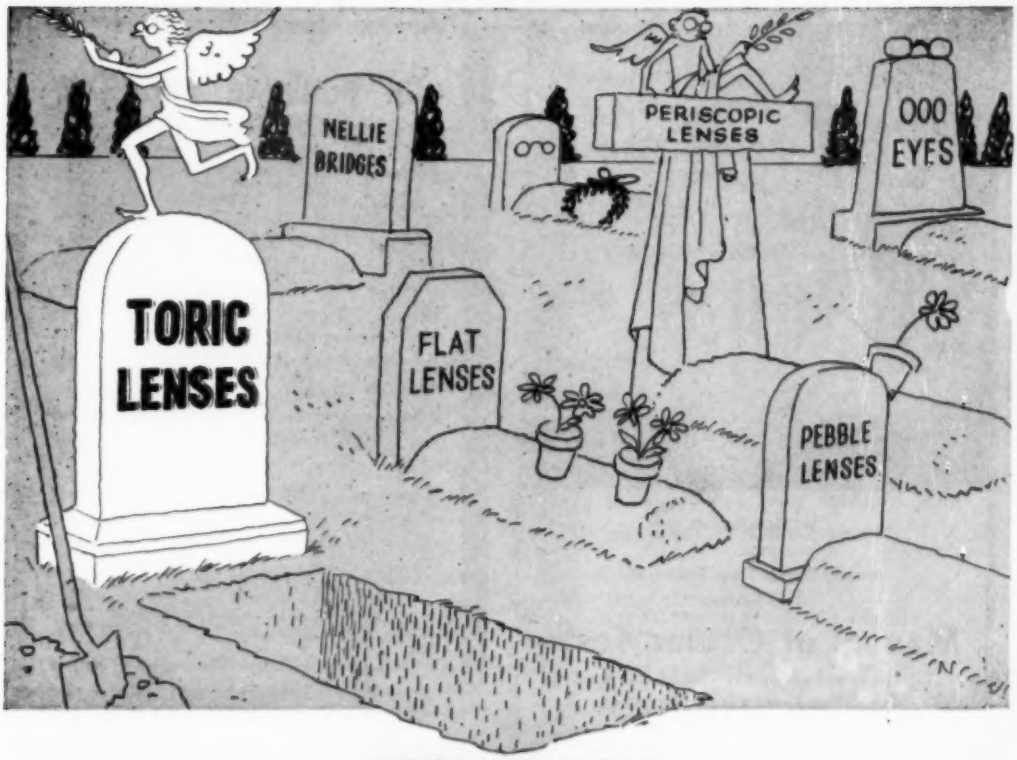
The following Committee has been appointed by President, Dr. Meredith W. Morgan, Jr., to raise the funds for the Sheard Commemorative Volume and to supervise the publishing of the coming book for the Academy. Because of the significance of this event to both optometry as a profession and to the Academy, Dr. Morgan has assumed the Chairmanship of the Committee himself. The members of the Committee in addition to Dr. Morgan are: Dr. I. M. Borish, Kokomo, Indiana; Dr. Walter I. Brown, New Bedford, Massachusetts; Dr. Glenn A. Fry, Columbus, Ohio; Dr. Richard M. Hall, Cleveland, Ohio; Dr. Ernest Hutchinson, Los Angeles, California; Dr. Carel C. Koch, Minneapolis, Minnesota; Dr. Don R. Paine, Topeka, Kansas; Dr. M. Steinfeld, Paducah, Kentucky; Dr. E. LeRoy Ryer, New York, New York; Dr. Arthur P. Wheelock, Des Moines, Iowa, and Dr. Eugene Wiseman, Buffalo, New York.

CHAPTER ACTIVITIES

SAN FRANCISCO BAY AREA CHAPTER

Dr. David Fleming of the Department of Physiology of the University of California was the speaker at the May meeting of the San Francisco Bay Area Chapter. Dr. Fleming gave an interesting discussion on the role of the sympathetic nervous system in visual accommodation.

Since January, the following men have been elected to membership in the local chapter: Drs. Ferd T. Elvin, Oakland; Kermit K. Kors, San Rafael; Merton C. Flom, Berkeley; Gordon G. Heath, Berkeley; Allan N. Freid, Berkeley; Albert C. Stoltze, San Francisco; Lester A. Fourness, San Francisco; and Allan B. Colt, Oakland. Dr. Darrell B. Carter is Secretary of the Chapter.



ISN'T IT TIME WE BURIED THIS ONE, TOO?

Optical people the country over are beginning to realize that the six-base lens is a dead duck – that advances in lens manufacture during the past few years have provided a better, more scientific product for the professional man's prescriptions. Many refractionists have recognized the value of corrected lenses and prescribe them regularly. This, in turn, has upgraded professional services in many areas, but the *big* job – that of converting *completely* to the modern corrected lens – is yet to be done. Today's standard in corrected lenses is Orthogon, designed to correct for marginal astigmatism below the limits of physiological perception. Orthogon curves are *standard* in Soft-Lite. In single-vision, Panoptik, ST, Orthogon C. D. F and many other multifocal types, Orthogon curves are *another* point of superiority of Soft-Lite over imitations. Isn't it time we buried the old-fashioned toric lens in favor of the *modern* standard?

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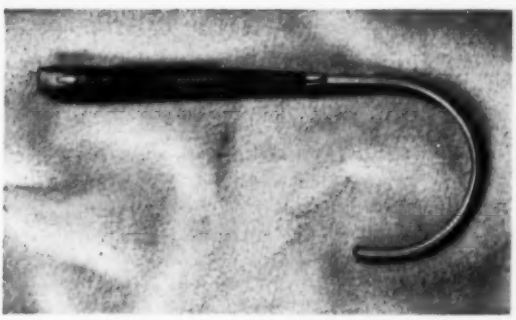

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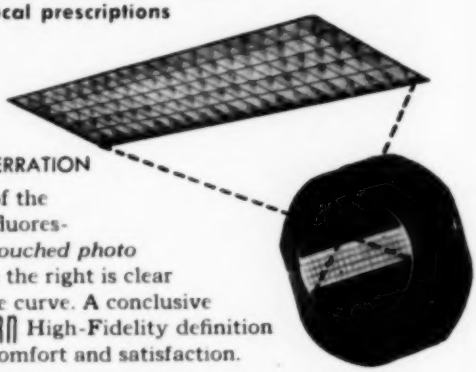

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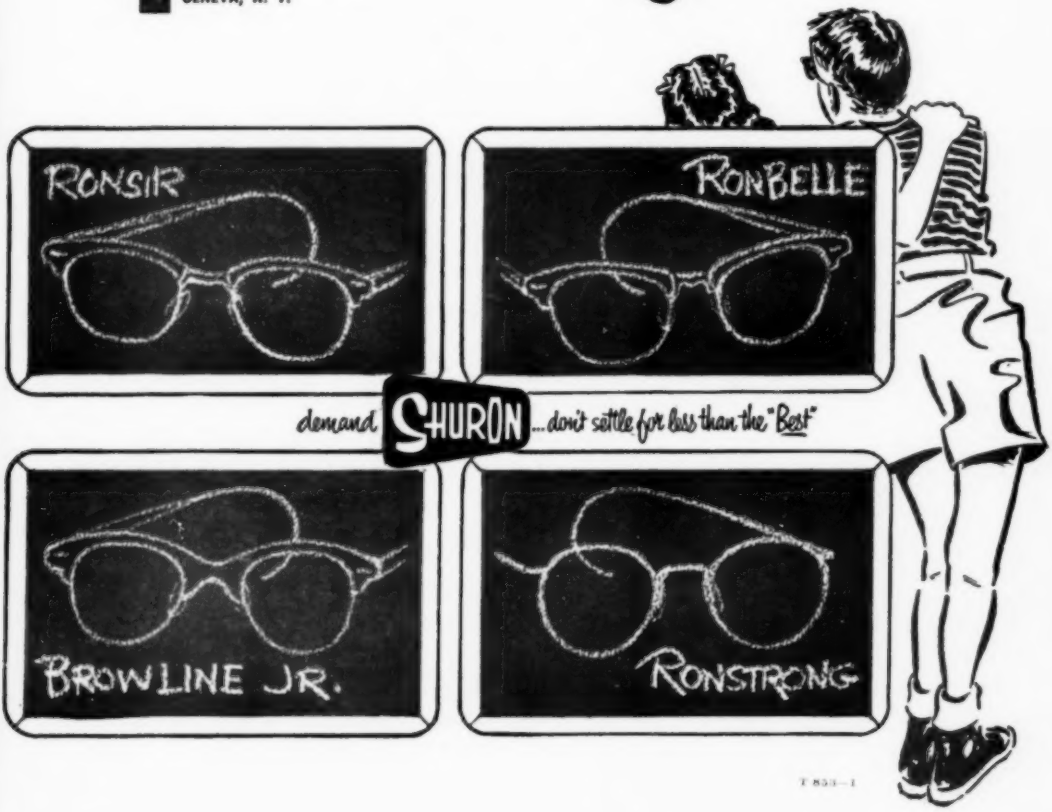

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